

DESERT TRAILS
OF ATACAMA

ISAIAH BOWMAN



AMERICAN GEOGRAPHICAL SOCIETY

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Desert trails of Atacama,



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THE OASIS OF MATILLA

The first and last impression of the desert towns is enduringly pleasant. From the desert trail, long, hot, and deep in dust, their inviting gardens are seen many leagues away, and at night a tower light on a commanding hill-top guides the traveler to their hospitable gates. Rows of refreshing orchard trees, neat squares of vegetable gardens, and a life-giving stream with clustering houses—that is the picture. In the twilight of morning and evening the strong contrast of yellow plain and deep green foliage is most marked and lends to the view, in that otherwise cheerless land, an indescribable charm.

AMERICAN GEOGRAPHICAL SOCIETY

SPECIAL PUBLICATION NO. 5

Edited by G. M. WRIGLEY

DESERT TRAILS OF ATACAMA

BY

ISAIAH BOWMAN

Director of the American Geographical Society



AMERICAN GEOGRAPHICAL SOCIETY

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CONTENTS

CHAPTER	PAGE
I PIONEER FIELDS OF DISCOVERY	1
II A DESERT JOURNEY	11
III RAINFALL OF THE DESERT	40
IV POPULATION GROUPS OF THE NITRATE DESERT . . .	60
V POLITICAL GEOGRAPHY OF ATACAMA	83
VI THE SOUTHERN MARGIN OF THE DESERT	96
VII EARTHQUAKES IN COPIAPÓ AND THE ROARING MOUNTAIN OF TOLEDO	143
VIII THE INFLUENCE OF MINING ON A DESERT SETTLEMENT	162
IX EASTERN BORDER TOWNS	186
X THE SMALLER INTERMONT VALLEYS: THE LIVE STOCK TRADE WITH BOLIVIA	202
XI THE CHACO COUNTRY AND THE CATTLE TRADE WITH THE NITRATE DESERT	218
XII SAN PEDRO DE ATACAMA	236
XIII THE PUNA DE ATACAMA: LAND FORMS, PASTURE, AND WOODLAND	252
XIV CROSSING THE PUNA DE ATACAMA	275
XV PUNA SETTLEMENTS	294
XVI HABITABILITY OF THE PUNA IN THE PAST	310
XVII THE GEOGRAPHICAL SIGNIFICANCE OF THE PUNA . .	328
XVIII THE HISTORICAL BEARING	343
INDEX	349

SEPARATE ILLUSTRATIONS

PLATE		
I THE COPIAPÓ AND VALLENAR VALLEYS (3 photographs)	opp.	110
II BORDER OF THE CORDILLERA AT ROSARIO DE LERMA (2 maps)	opp.	192
III THE PUNA DE ATACAMA (3 photographs)	opp.	278



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PREFACE

I have attempted herein to describe and interpret a region, traversed on three field expeditions, which has more strongly attracted me than any other part of South America—the Desert of Atacama and the high ranges and plateaus of the Central Andes which end in the Puna de Atacama on the south. The narrative is brief, personal experiences being introduced, as a rule, only when they serve to complete the geographical picture. Near the southern end of the desert are the towns of Copiapó and Vallenar, and the longest chapter is devoted to their fascinating life and especially its pioneer character. Of equal interest to the geographer is the girdle of settled country that runs about the high and cold Puna de Atacama. I have not limited the story to the desert country alone but have included a brief account of the Chaco or grasslands of northeastern Argentina and adjacent Bolivia, because the currents of business flow naturally from these border settlements across the Atacama country and deeply affect its life.

My grateful acknowledgments are due the Editor, Miss Gladys M. Wrigley, who has performed her task in so constructive a manner as quite to transcend the usual editorial function, supplying many historical data, especially in the chapter on mining, and giving the whole work logical arrangement and precision. I am also indebted to Miss Elizabeth T. Platt for her scholarly assistance in assembling reference material; and to Lt.-Col. Michael Kostenko, who in his craftsmanlike compilation of the Iquique, Atacama, and Coquimbo sheets of the American Geographical Society's Millionth Map of Hispanic America has supplied a most helpful basis for geographical research in the Atacama region. It is a pleasure to record my obligations to Yale University under whose auspices two of the field expeditions were carried through. To the Officers and Council of the Society I desire to express my heartfelt thanks and appreciation for their support of field work in South America and their interest in this as well as my earlier and more technical publications on the region.

ISAIAH BOWMAN

CHAPTER I

PIONEER FIELDS OF DISCOVERY

The geographical explorer seeks not merely new or wonderful things; indeed his main object is not that at all. If he steers a course to distant lands it is because he wishes first of all to make discoveries, whether these are wonderful or not, out beyond the realm of accustomed life, or as Colonel Roosevelt put it, "beyond the rim of the known world." Real exploration can also be done in one's own garden, as Darwin demonstrated in his classic study of earthworms. Agassiz, walking over the rounded New England hills and drift-strewn valleys, discovered the fact of continental glaciation in a vanished Ice Age, where others still speculated about the Noaic deluge. He said simply, "If this were in Switzerland I should say the ice had been here." Before he came to New England he had "explored" the fish collections of Cuvier at Paris. Whatever he did was noteworthy because it was related to the discovery or exploration of a moving idea. The adventure and sport of exploration are but a fleeting record compared with contributions to knowledge, for they are the incidents on the way and not the goal of exploratory research.

It has become the fashion to say that major exploration is at an end because the North Pole and the South Pole have been attained and the general design of the mountains, deserts, and drainage systems of the earth has become known. Yet in truth the map is still crowded with *scientific* mysteries though its great *historic* mysteries have been swept away. The Mountains of the Moon, the sources of the Nile and the Congo, the secrets of the inner Sahara, the heart of Tibet, these are among the great mysteries that long awaited the explorer and that have been dispelled one by one.

Has the age of discovery ended with these exploits? Before we can answer that question we must know what constitutes a *discovery*. It is undoubtedly an achievement to fill in a blank

space on the map; but discovery has not ended when the blank spaces are filled, for, after all, the map is but a sheet of paper upon which we place symbols and lines that stand for realities and their surface arrangement, such as a river or a mountain or a city; and it is the character of the mountain, the peculiarities of the river, the conditions of life and the relations of the people who live in the cities, or in fields on the plains, or along river banks and in mountain valleys, and who transport, manufacture, and perhaps have political relations and boundaries, ports, colonies, and the like, that are of abiding interest. The stage upon which humanity plays the great game of life is an important thing, but the play is much more important. Discovery can hardly be said to be ended until we have studied every people in the world in its peculiar physical setting, made nations known to one another, and perchance lessened our troubles by revealing us to ourselves. Long before the sources of the Nile were discovered by European explorers there were people living about the headwaters of the Nile. Indians had roamed the forests of the Rio Roosevelt for centuries before the discovery in 1913 of that thousand-mile river in the heart of the Amazon country. The Quechua and Aymará Indians of the Central Andes have passed almost daily in and out of the ruins of buildings that their ancestors constructed centuries ago but of whose existence we were unaware until the present generation. Until facts like these have been discovered and their exact character made known through published records, they are the exclusive possession of merely primitive peoples. They have not yet been discovered by science.

It is in this sense that the geographer undertakes the study of new lands and regions today. For him the world is far from being explored. Until a few decades ago we had almost no accurate scientific information about the distinctive conditions of life in South America, or about the distribution and character of people who found it difficult either to achieve or to keep a national unity. Until two decades ago the physiography of the great Andean chain was almost completely unknown. We were aware of the length and breadth of the mountains, the sources of the most important rivers, the heights of passes and

peaks, but we knew nothing of the exact nature and history of the mountain forms. No one had up to that time given us a picture of the mountain landscapes in modern terms; that is, in terms that conveyed exact impressions and in contrast to the vague, general terms such as the casual traveler may employ in painting a picture that makes a special appeal to him.

THE FIVE MAIN FIELDS OF EXPLORATION

The desert has furnished one of the five main fields of exploration in historical times, the other four being the polar regions, the unknown mountains of the world, the tropical forests, and the islands of the sea. Mountains were once objects of veneration and awe and even of worship. Many peoples considered them the abode of evil spirits. Their dark defiles, their great uninhabited spaces, their wild storms, all of which have excited the imagination and attracted the explorer in modern times, were fearsome things to the plains dweller who knew the mountains only by reputation or by legends that came down to lowland cities from mountain folk or from passing travelers. Where the modern man goes voyaging for adventure and pleasure among distant and little-known islands in remote parts of the sea, there the European at the dawn of civilization saw only outer darkness or the abode of strange peoples and listened to legends of islands that were said to have vanished beneath the ocean. Equally strange as distant islands, equally fearsome as the mountains, were the vast inner recesses of the tropical forests when their margins first became known to the explorer and the settler. The sources of the great rivers that flowed through them were in most cases unknown, and quite unknown at first were the peoples who lived on their banks or in clearings in the forest. For a long time it was believed that the Amazon forest was the home of the strange folk that legend had pictured, and one expedition after the other went out to find them. The extraordinary animal and human life of the central African forest long furnished one of the greatest incentives to exploration, an incentive that draws men even today. The conquest of the poles of the earth, like the conquest of high mountain

peaks, has had in it a large element of science and the search for knowledge but also an equally large element of sheer adventure and sport, for it has required physically well-trained men, willing to adopt special modes of living and special diets, and also men of imagination who could work long and arduously for the sake of a record. It is no dispraise of the scientific results of explorers to say that the appeal of exploration in many cases has been to the romantic and adventurous rather than the strictly scientific, though the name of science is always invoked to strengthen each new enterprise. Peary put the case more frankly. He thought the attainment of the North Pole by an American a matter of patriotic pride and that the way to get there was to live like the Eskimo, have exceptional powers of endurance, and expend unlimited muscular energy.

It is altogether a modern thing to look at the great objects of exploration from the purely scientific standpoint. David and Mawson in the Antarctic and Stefansson in his Arctic work of the past decade have done this. It was characteristic of Colonel Roosevelt that he should never be carried away by his narrative, or the adventure which he was living, to such an extent as to overlook the scientific value of the thing he was observing. Everything that he wrote bears the stamp of the pioneer spirit. He was curious about the pioneer. He wanted to see how he lived, how he met the special conditions of his environment, whether of frost or heat or flood or drought; and, above all, he was keen about the motives that lay back of that restless energy which the pioneer has always displayed and that independence of spirit that has made him so great a factor in history. Both his African and South American journeys have yielded notable *pioneer* studies, and his observations on western life and especially his historical studies in the "Winning of the West" are contributions of a high order. Livingstone was for a long time almost alone in having an unquenchable interest in the frontier of modern life in Africa and the effect of the oncoming wave of civilization upon the native peoples whom he knew and loved. That is why his writings will have a classic interest long after the romantic and adventurous work of others shall have passed into comparative forgetfulness.

To my mind, the desert is the most interesting place in the world for exploration and geographical study. This is altogether a matter of personal taste and to that extent at least will not require an explanation. Far from being uninhabited, every desert has a great many people in it and a great many more who live just on its borders, where they are grouped in communities that trade with the larger cities and towns of the wetter regions near by and the still smaller cities and towns of the desert interior. They take great risks with the rain. Now they have years of plenty, and again they have years of drought and distress. How came a desert people to seek so severe an environment? So long as the well-watered lands will support more population, why do some go into—or remain in—the desert? There has been estimated to be many millions of people living in the deserts of the world, the Sahara alone supporting two millions within its borders. Of the fifty million square miles of land surface on the earth one fifth, or ten million square miles, are desert. It may seem surprising that anyone should endure the risk and distress of desert living until we remember that desert folk are not scattered over bare rock and lifeless sand but live grouped in oases for the most part, where their gardens look as prosperous as those of Connecticut or Virginia. Just as mountain people live in valleys among the mountains and not on mountain peaks so desert people live in the watered spots and not on the sand dunes. Though we hear much of the nomadism of the desert, there are far more desert dwellers living on farms than there are living from wide-ranging flocks and herds. And even the nomad generally winters or summers, according to the quality and time of the rains, in some home site where for a time at least he leads a more settled life.

THE DESERT AS A GEOGRAPHICAL LABORATORY

Any land that has severe conditions of life is a geographical laboratory. If men there take risks with nature they can survive only by adapting their life accordingly. Again, every desert settlement tends to fill up. When a desert valley has been

filled with people by the natural growth of population or by immigration from elsewhere, what is the mode of escape? Neighboring valleys and oases are often themselves filled up, and the horizon of a humble farmer or shepherd rarely includes the distant and strange places that are the centers of industry, where population can be absorbed in increasing numbers. In such a small isolated world what changes of social structure are brought about by the pressure of population? These little desert communities are to a large degree self-governing. To what extent have they adapted their home-made regulations to meet the trials of the years of drought? When the rains fail and the cattle die and trade becomes dislocated and feeble, how is the social and business structure maintained?

It is natural to look to war as a relief from the pressure of population. But, as a matter of fact, war offers very little relief from such pressure. The feuds and raids that exist among many desert folk involve a certain percentage of loss by violent death. Hard conditions of life themselves tend to hold the population down by limiting the birth rate in one way or another. Great changes of climate may bring about a general movement of population, and we have seen this illustrated by the sharp droughts of the past few years in the Samara region north and northwest of the Caspian Sea, when hordes of Russians moved west and north into the more favored sections in their search for food. But while such a driving forth of a desert people may have been brought about, I think the effect of it upon history and the social structure has been altogether exaggerated, perhaps largely because it is a picturesque and violent proceeding that appeals to the imagination.

But a picturesque event is oftentimes utterly trivial in its effect upon the character of a people and its modes of gaining a livelihood. If history is a record of picturesque incidents, then the driving forth of a desert people by increasing drought is an important fact. If, on the other hand, history is a record of the growth of culture and ideas, then a given migration from a drought-stricken desert may have very little significance. The fact that a people has gone forth is in itself not to be taken as establishing the importance of the event. If it goes steadily

forth and carries a significant culture into bordering communities or is itself absorbed by bordering communities that are altered in the process, then the migration is of very great importance. I think we have too long assumed that the mere movement of peoples is the important thing, whereas the truth would appear to lie at the opposite extreme. If the effect of the migration is important, then the migration is important; but it must be first shown that there has been an effect.

Whether or not migrations have affected the life of a desert people, that life tends to go on living up to the limit of its known resources and to use them with all the intelligence at its command; so that those who stay in desert valleys and oases live a self-contained life.

IS MAN THE CONQUEROR OR THE CONQUERED?

On the western, or seaward, border of the great Andean chain the desert holds sway for nearly two thousand miles. Down into the border of the desert come streams from the higher country where snows and summer rains give birth to a multitude of mountain torrents. The villages and tiny settlements lie scattered along the foot of the Andes. Each community lives a life unto itself. Isolation is here an outstanding fact, traffic with the outside world being both feeble and irregular. All the settlements exhibit social and political organizations shaped by the geographical conditions that surround them. They are locally famous for this product or that and, though far away from the great centers of commerce, are not wholly unaffected by modern civilization. We are not to imagine because a railroad has been built near by or a mine has been opened calling for such labor as the desert can spare, that a desert community has been revolutionized. Even in such cases nature continues to stamp her character upon the life of the desert dweller. I wish to emphasize this point because it is customary to say when man has built a railroad into the desert or the mountains that he has conquered them, that thereby man is bending nature to his will, that he is annihilating what formerly frustrated him. But even if railroads are run across the

mountains or the desert reclaimed by scientific methods of investigation or rubber gathered, as it was until recently, in enormous quantities in all the highways and byways of a once impenetrable forest, still all these are done by such methods and at such an expense of human energy and of capital, even of life, as to make them examples not of sheer human conquest but of a conditional conquest. Because of the urgency of his need, man in the temperate zones penetrates the unfavorable environment of desert and tropical forest and meets difficulties by new means, chiefly through the expenditure of money. The railroads that cross the Andes have not overcome the mountains; they are paying toll to them. Every pound of coal, every mile of grade that must be overcome, costs man so much the more and reduces the profits of his enterprise or increases the tax upon the resources of all those who contribute to the commerce which the railroad carries.

The historian Buckle was measurably right, therefore, when he entertained the view that the backwardness of South Americans was due to the fact that man was there overburdened by nature as upon no other continent. The tropical forests are too vast, in Buckle's view, the mountains and plateaus too high, the deserts too arid for man's successful conquest. Now the railroads have come, many great mines have been opened, the population has been vastly increased; but out beyond the sphere of influence of these things, in the isolated villages of the desert oases, and in lonely mountain valleys are still living unaffected groups that follow the old callings and ways of life.

The border of any desert is a long-enduring frontier. Four centuries, and at the end of them a railway, have not altered the essential pioneer quality of the life of desert communities like Calama and Copiapó; and to an even greater degree this is true of San Pedro de Atacama, Pica, Matilla, and Quillagua. Water remains a primordial basis of life; the state of the pastures is a topic as keenly interesting today as in the time of Valdivia and Aguirre; the mountain trails and the best seasons of passage over them are known to boy and man alike; the year of the last river flood is still the principal date of

reference for events in and about Copiapó and takes precedence over earthquakes in this respect, terrible as these have been; the sources of firewood, quarrels over water rights, the price of forage and cart or pack mules, the state of the snows in the cordillera—one or another is a daily theme of conversation and a running basis of business. The structure of such a community is of great historical as well as geographical interest. Loria, the Italian economist, holds that the history of colonial settlement is for economic science what the mountain is for geology, bringing to light primitive stratifications. "America," he says, "has the key to the historical enigma which Europe has sought for centuries in vain, and the land which has no history reveals luminously the course of universal history."¹

¹ Achille Loria: *Analisi della proprietà capitalista*, 2 vols., Turin, 1889; reference in Vol. 2, p. 15. Quoted by F. J. Turner: *The Significance of the Frontier in American History* (*Ann. Rept. Amer. Hist. Assn. for 1893*, pp. 199-227), p. 207.

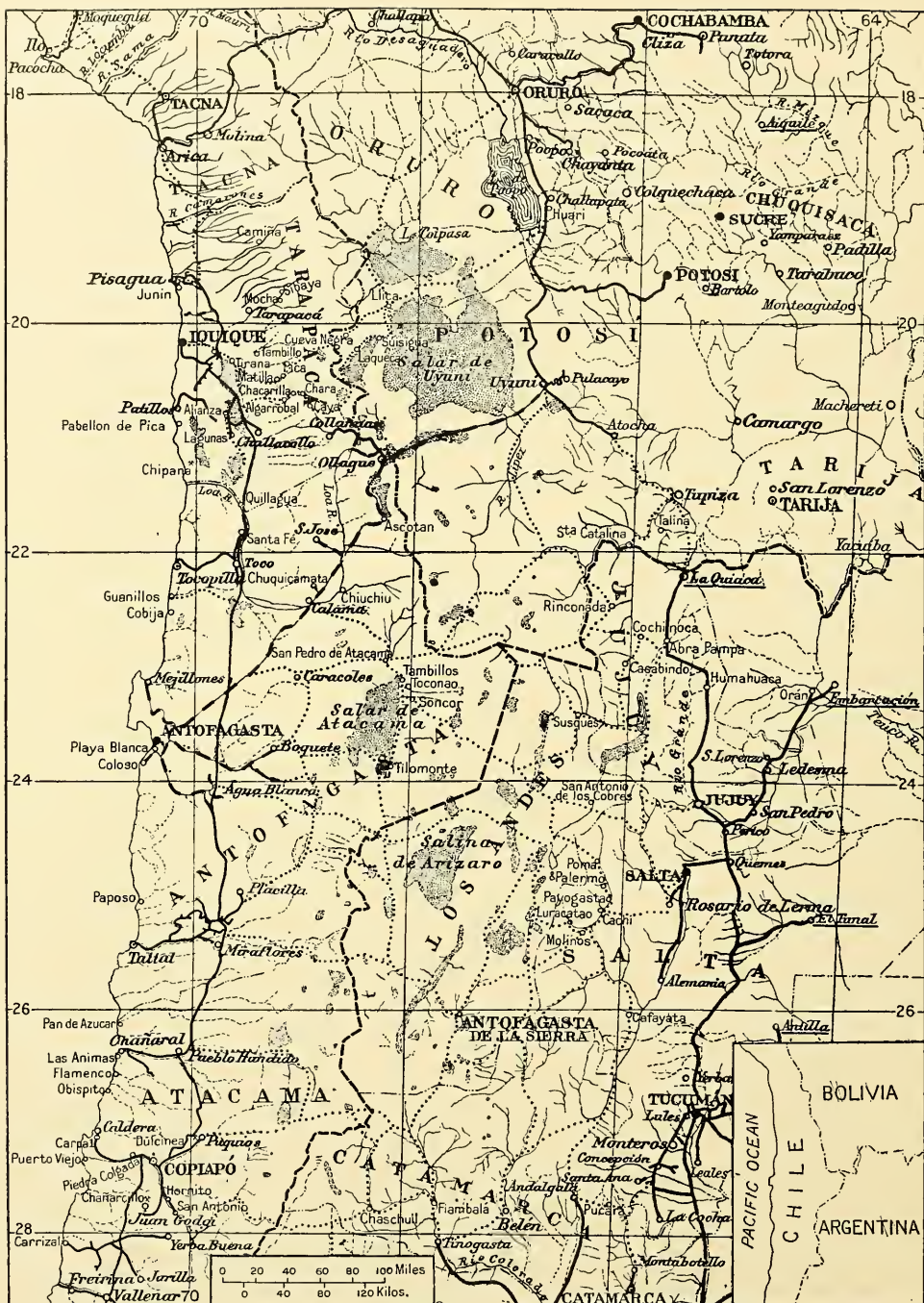


FIG. 1—General location map of the Desert and Puna of Atacama, in northern Chile, northwestern Argentina, and southwestern Bolivia. Reduced from the American Geographical Society's six-sheet map of Hispanic America on the scale of 1: 6,000,000 with additions from the compilation sheets of the Society's 1: 1,000,000 map. The heavy dotted lines represent the principal trails that supplement the railway network. See Fig. 86, p. 253; and Fig. 87, p. 259.

CHAPTER II

A DESERT JOURNEY

If the high and bold coast of northern Chile excites the imagination in these times, what must it have seemed to the sea voyagers of the sixteenth century, the hulls of whose tiny caravels would find ample room in a single smokestack of either the *Leviathan* or the *Majestic*! The so-called ports of northern Chile are either open roadsteads or occupy mere shallow bights in this forbidding coast, and the towns stand upon narrow marine terraces cut in a past age and now uplifted to form a narrow shelf that furnishes barely room enough for a settlement. In places two or three thousand feet of steep scarp, as barren apparently as if no rain ever fell, shut off all view of the distant mountains. There are no openings here and there where green valleys lie floored with cultivated fields as on the coast of Peru. It is a simpler coast than that farther north and far more desertic in aspect. The streams disappear for the most part in inland basins, and the coast is almost entirely without a touch of green. Except for one river, the Loa, there is not a single stream that reaches the sea in the 600 miles of territory from Arica to the mouth of the Copiapó River. There are dry *arroyos* that nick the great western scarp of the coastal desert, but they carry water only in times of highly exceptional rain separated by ten or fifteen and in some cases fifty years of drought.

THE DESERT LANDSCAPE

There is in northern Chile none of the scenic beauty that marks the change from bleak mountains to the warm, green valleys of the coastal desert of Peru. In the latter case the streams reach the sea, and the valley walls enclose cultivated fields that fill the valley floor. In Peru the picture is generally touched with color—a yellow, haze-covered horizon on the

bare desert above, brown lava flows on the brink of the valley, gray-brown cliffs, and greens ranging from the dull shade of *algarrobo*, olive, and fig trees to the brightness of freshly irrigated alfalfa meadows. In northern Chile there is no hint of water until one reaches the foothills of the Andes far beyond the Coast Range and across the intervening desert. Where



FIG. 2—The steep coast of northern Chile at the nitrate port of Caleta Buena. A cog railway connects the shore with the upper level which stands at 2000 to 2500 feet above sea level.

water occurs it is so small in volume that its effects are almost completely hidden in the depths of steep-walled ravines, so that in many places one may look for miles along the Andes without seeing a single trace of vegetation or human life.

To reach the desert of northern Chile from the sea one crosses by passes set almost at the crest of the Coast Range. These appear high up in the ocean view of the coast, but from the desert they are mere notches set in low and quite rounded hills with smooth contours. Beyond, the desert opens out, flat in places or gently rolling in the piedmont belt or broken

by a cinder cone or local lava flow. The broad plain of the nitrate desert is known as the *pampa* and is set between two mountain systems. On the eastern horizon the western range of the Andes (in the Iquique region) rises by a broad and rather regular slope to an even crest visible from the passes near the coast; on the west is the Coast Range.

On my first pack-train journey into northern Chile where the nitrate desert begins I was delighted to find all my expectations of desert scenery realized. For the first fifty miles there was but a single spot where a natural growth of green could be seen from the trail and but one other where there was any green growth at all, and that beside a desert well about which were clustered a few low huts. All the rest was naked rock and sand, brown and yellow in color yet appearing stark and colorless in tone in the midday sun when the whole landscape is overlighted; glowing with color as the sun declines and the shadows of the ravines come out. It is the end of the day that brings out the colorful mood of the desert. The afternoon winds raise huge clouds of dust, and, as the sun's rays filter through the murky atmosphere at sunset, they range from lively yellow at the beginning to violet, which in turn deepens gradually to a series of purples that glorify the sky for a short half hour until displaced by the grays that deepen into night.

At the eastern edge of the desert there are in places mountains of great topographic simplicity, as east of Iquique; while in other places they show great complexity, as where deep canyons bordered by variegated rocks nick the high mountain wall with its crown of volcanoes and wide bordering volcanic flows. The snows of the higher cordillera give the summit peaks a clearer outline against the dark blue and purple background of the sunset sky in the east. From the mountains the desert plain appears to extend indefinitely westward and to have a much wider range of color and form. Distant and lonely a village stands on a narrow terrace at the canyon border, its green barley and alfalfa fields ending at the edge of an abrupt scarp where the floods of the rainy season and those from the melting snows tear holes in the defensive ram-

parts that the villagers have built to protect their precious acres from these "acts of God." In the great hollows at the heads of the canyons are natural pastures, and there under the cliffs the traveler finds shelter from the cold down-valley winds of night.

Many leagues of dusty and stony trail must be traveled between oases, but there is scarcely a single valley of im-



FIG. 3.—Pack train in the desert above Pica in northern Chile.

portance that does not have commercial connection with distant places on the other side of the mountains in Bolivia and Argentina. In such a country every wayfarer is immensely interesting. One's route and purpose must become known to all before the flood of questions subsides. The life of the village is turned inside out for you. If there seems to be only abounding hospitality it is no derogation of the native's spirit to say that the traveler pays for his hospitality in news. When there is no morning paper to be had the stranger within the gates is a lively substitute. New York seems friendly and romantic only on the rarest occasions and in rare moods, and one of these is when the traveler returns from the wilderness. He can then appreciate what he himself means to the man in the desert or the distant mountain village when a strange pack train swings into the head of the one tiny street that marks the order of a town.

The deserts of the world are not lifeless places, although lifeless tracts of more or less limited extent can be found in

almost all deserts. In northern Chile where is the driest climate in the world there are villages, because even there the desert is not absolutely rainless, and where there is rain there are streams and settlements beside them. It is the rarest occurrence to find a watered spot in the desert that has not been settled by man.

THE NITRATE PAMPA

For the pack-train journey across Atacama, the desert of northern Chile, I obtained mules and guides at the nitrate plant of Central Lagunas east of Iquique. Through the kindness of the British Consul there and of Mr. Watson, the manager of his nitrate works on the pampa, we were prepared for a journey of several weeks and set out early in May for the pass at the southern end of the Cordillera Sillilica, which, between latitude 19°S. and 21°S. , constitutes the boundary between Chile and Bolivia. Our guides were workmen from the nitrate establishment and were supposed to know the mountain trails, but in reality they were as ignorant of them as we were. From the Consul, who had been over a portion of our route, we obtained a description that was of far more value than the knowledge and advice of the guides. The first day's journey, including a short stop in the late afternoon at the pumping station on the pipe line to the coast, took us to Matilla. Soon after we rode out from the pleasant shade of the station we entered the edge of the piedmont slope formed of mountain detritus washed into place at times of heavy rain or of melting snow in the mountains when the streams come down in torrents. Our course for an hour or more was along this slope rather than across it, and in this stretch we saw men digging fuel from the ground and loading it upon wagons from the station—an astonishing way in which to get firewood! All the more curious is it to hear the phrase “mining for wood.” Even at the present day the *leñador*, or woodcutter, is a typical figure in the desert region, and his searches for the commodity of his trade, as those of the mine prospector, have contributed to the exploration of this inhospitable country.

EXPLOITATION OF FIREWOOD

The Pampa del Tamarugal, which runs from the latitude of Pisagua to the River Loa, differs from the desert tracts on either side of it in having more abundant ground water and a higher water table. In the Lagunas salar it is only three and a half feet from the surface. Today the Pampa still retains fragments of what appears to have been a more extensive thorn-woodland cover, characterized by tamarugos, algarrobos, and other drought-resisting species, that is represented on some of the older maps and described in early records. Frézier reports that in 1712 there was near Calama a forest of algarrobos where vegetation is now almost entirely absent.² San Roman saw in the southern Desert of Atacama dead forests of algarrobo in the sand. They were dug up for firewood.³ Plagemann notes the existence of algarrobo forests sixty or seventy years ago close to the village of Tarapacá where now is complete desert.⁴ People of that village supported their troops of sheep by allowing them to eat the fruits of the trees. Much of the wood appears to have been cleared in the latter part of the eighteenth century to aid in a new desert industry, the exploitation of nitrate from Tirana for the local—and illegal—production of gunpowder and also for the reduction of ores.⁵ The present exploitation of wood at Tarapacá depends chiefly upon algarrobo trees brought down by mountain streams where the shifting of piedmont stream channels had undermined *algarrobales*, that is patches of algarrobo woodland. One should not make the mistake of thinking that this means necessarily a change of climate. A shift in a piedmont stream might leave a long tongue of algarrobo forest without water and kill it off, floods of a later epoch burying the fallen trunks. The drifting of sand, the alleged increase of salt deposits, and possibly a change of climate have helped bring about the disappearance of the forests.

² Frézier: Relation du voyage de la mer du sud aux côtes du Chily et du Perou fait pendant les années 1712, 1713 et 1714, Paris, 1732, p. 131.

³ F. J. San Roman: Desierto i cordilleras de Atacama, 2 vols., Santiago, 1896; reference in Vol. I, p. 191.

⁴ A Plagemann: Der Chilesalpeter, Berlin, 1904, p. 17.

⁵ G. E. Billingham: Estudio sobre la geografía de Tarapacá, Santiago, 1886, pp. 31-32.



FIG. 4

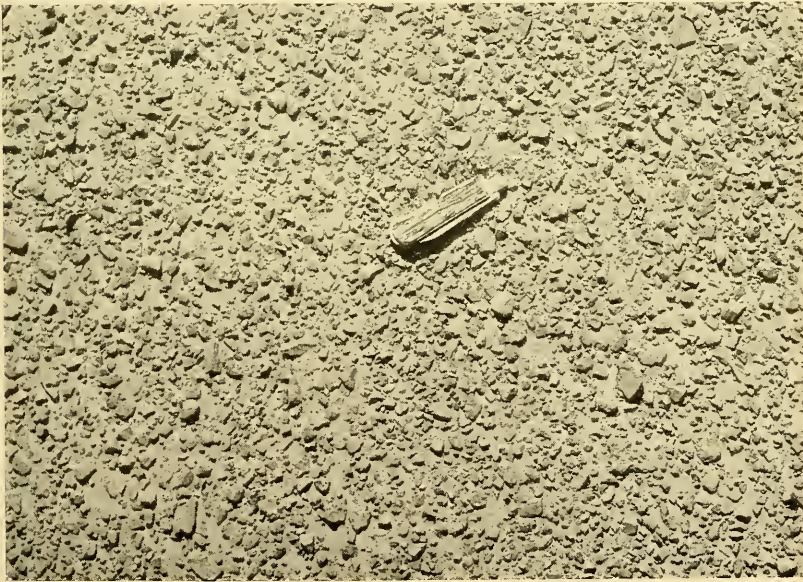


FIG. 5

FIG. 4—*Médanos*, or sand dunes, marching eastward up the piedmont slopes on the western border of the Central Andes east of Pica (see Fig. 1 for location). They are formed and driven by the regular afternoon wind from the sea that generally blows with gale strength.

FIG. 5—The so-called “desert pavement,” the finer material being blown away leaving the coarser material as a protective covering.

It is certain that algarrobo played a great rôle in the food supply of the former inhabitants of the Desert of Atacama, as it did on the other side of the mountains. Fruits and many objects made of algarrobo wood were found by Éric Boman in the graves of Calama.⁶

PIEDMONT OASES

For several miles in the piedmont stretch our trail crossed dry baked mud flats where the flood waters are impounded in shallow reservoirs according to the natural depressions of the ground. The tops of the blocks between the mud cracks are curled upward and break into thin flakes along the bedding planes as the mules' hoofs dislodge them. A strong wind had been blowing from the sea during the afternoon, and it had drifted sand from near-by sources over the mud-cracked surface, filling in the spaces between the cracks and the curled edges of the plates. It is by such means that the geologist, studying mud layers visible in the rocks formed in remote geological ages, determines past climates and other conditions of formation in places that now may have plenty of moisture.

Beyond this point we rode farther into the piedmont and entered more broken country where we experienced great difficulty in keeping the trail, for each traveler had apparently taken his own route. From the summits of the ridges between the shallow valleys we could now look over the whole width of the nitrate pampa and see the low hills of the Coast Range outlined against the dark haze, the top of the fog bank, that hangs over the edge of the Pacific. The desert trail where it crosses the *salars* appeared broad and white in contrast to the darker yellow and brown of the untraveled pampa and could be seen for a distance of at least fifteen miles. The bright yellow light of sunset gave place to purples that seemed almost to creep out of the mountains and the sky above them until we could see at first faintly and then more clearly the lights of the nitrate works at Alianza on the western border of the nitrate fields. There

⁶ Éric Boman: *Antiquités de la Région Andine de la République Argentine et du Désert d'Atacama*, 2 vols., Paris, 1908; reference in Vol. 2, pp. 713-714.

was no moon, and the darkness came rapidly down to make the going still more difficult. At the summit of every rise the guides would look about for the light at Matilla, and presently they located it. It is set up in a wooden tower to guide the night traveler, who would otherwise be lost in the maze of ravines. By three in the morning we reached the floor of the Quebrada de Quisma opposite Matilla, but in the darkness we could not find the ford, and, fearful of the river sands, the guides thought it best to make camp there. We set fire to a dry bush and by its light, as that of a huge torch, prepared a meal and staked out the mules. (For illustration of Matilla see Frontispiece.)

The next morning we found the ford but a hundred yards away, crossed over to Matilla, and rode on to Pica where we spent the day. Here we obtained additional blankets, brought in regular trade from Bolivia by llama caravan, and added to our stock of provisions. The next day took us across the drifted sand tracts east of Pica (Fig. 4) and to the wells at Tambillo, the last outpost of the desert in the Andean foothills.

WATER SUPPLY OF THE OASES

The village of Matilla is supported by a thin thread of water that issues from the so-called mountains far above, the Altos de Pica. They are really a plateau and part of an even surface that extends for thirty or forty miles along the Andean crest. Halfway up their slopes one comes upon the edge of a belt of grass that denotes a rainfall slightly heavier and, of still more importance, *regular* in occurrence. It is a mid-mountain belt of annual rains and permanent pasture. Almost before we had time to note the first spears of grass at about 8000 feet we also noted the first bird calls we had heard since we left the coast with its bewildering millions of sea fowl. A little higher and we came to an old and now abandoned corral and camp site where the mountain shepherds from the eastern, or Bolivian, side of the Andes had camped in traveling down to the desert towns and ports or had pastured their llamas for a time. From out this zone of grassland several streams run to converge in the Quebrada de Quisma where Matilla lies.

At Pica, on the piedmont slope to one side of the stream courses, tunnels have been built into the piedmont deposits and carry the water by low gradients down to the intake of the pipes and canals that distribute it. We rode up to the intake of one of these (La Vertiente del Resbaladero) and saw the pool at the foot of cliffs partly encircling a cavelike opening. It was at that time the chief point of interest in the town. A similar system of water recovery has been built in the desert places of other countries. In Persia such a subterranean conduit is called *kanat*, in Baluchistan and in Turkestan *kariz*. In Tidikelt and other provinces of the Algerian Sahara it is called *foggara*, and all who have worked to increase its yield have a share in the flow. A recent account has been given of the pits and connecting galleries called *rétharas* in Morocco.⁷ A great water tunnel over a mile long has been built near a dry stream bed close to the Khojak Pass in India; and southern California has a number of like tunnels, some with "weep holes" where the water discharges into the main opening.⁸

The entire system of galleries or tunnels at Pica is one of great variety of structure and flow, and I know of no other town in South America that has so many of them or that depends so completely upon the artificial recovery of the ground water for both its drinking water and its irrigation. The galleries have been cut in a soft sandstone which is yet sufficiently hard to stand up under its own weight and to support a roof of the same material. Only in certain places in a few galleries is a small amount of timbering or stonework necessary. Some are lighted for a part of their length and carefully kept up, others are dark and interrupted here and there by falls of sand or soft rock from the roof or the somewhat overhanging upper walls. From the largest gallery, the Galería Comiña, water is supplied at the rate of more than one and a half liters a second; but its earlier rate was four liters a second, the decrease being due to the failure of the owners to keep the floor clear and the intake sufficiently open. Some of the galler-

⁷ Pierre Troussu: Les rétharas de Marrakech, *France-Maroc*, Vol. 3, 1919, pp. 246-249.

⁸ A. P. Davis and H. M. Wilson: *Irrigation Engineering*, 7th edit., New York, 1919, p. 59.

ies have become blocked, and the water collects in pools back of the obstructions. In all, there are at least fifteen principal galleries in the Pica region. They have a total length of 12,980 meters, or eight miles, the Galería Comiña alone being 2350 meters in length. The shortest is the Botijería, 100 meters long. The total discharge of the fifteen principal galleries is 36.37 liters (9.5 gallons) a second. Besides the fifteen galleries, or tunnels, there are eight principal springs with a discharge of 118.98 liters (31.5 gallons) a second, or three times as great as the discharge from the artificial tunnels or galleries, though these have been produced at such great labor and expense.

The galleries, or tunnels, have been built in part by the village of Pica, in part by private individuals for purposes of irrigation, and in part to supply water for the pipe lines that run to desert stations and to Iquique. Some of them have branches to augment the supply, some of them end in abrupt walls of earth from which the water oozes, others have an indefinite ending where the tunnel reaches a fault or penetrates a water-bearing stratum from which a supply of water is derived. Others still are terminated in a series of ascending slopes in order to furnish a larger area of "bleeding" surface to supply the main canal.⁹

The supply of water from tunnels and springs is variable; but the supply from the springs is much more constant, for the feeding spaces in the subsoil are of natural origin. This is an important point to keep in mind in interpreting the diminished flow which is reported from many of the tunnels and which has led to the abandonment of some of the cultivated fields, or *chacras*, that they supply.

Unlike most desert towns Pica stands in the midst of the desert without the green valley that elsewhere gives a natural basis for settlement. From its wells and springs and a reservoir in the course of a small stream descending from the piedmont the closely compacted gardens of the village are watered with scrupulous economy. We walked about the fruit orchards and irrigated patches of vegetables and grass, chatted with several

⁹ J. Brügger: Informe sobre el agua subterránea de la rejion de Pica, *Publs. del Servicio Jeol. No. 3*, Minist. de Industrias i Obras Públicas, Santiago, 1918.

of the officials who called on us, and talked with a most intelligent schoolmaster from southern Chile. The town is but little disturbed by the government taxgatherers; and in the worst years, as when the stream dwindles or the dam breaks and ruins both fields and crops, taxes are remitted altogether.

THE CORDILLERAN SLOPES

From each oasis on the desert border a trail climbs the cordilleran slopes. In places it follows the stream bed. In other places it runs along the flat interfluves or climbs perilously along the steep side of a deep ravine. In some cases two trails are in use, as in the case of the Quebrada de Tarapacá between Mocha and Sebaya, where the valley trail is impassable during the flood season when sudden deluges fill the narrow passage of the gorge. More commonly this duplication of trails is a feature of the Eastern Cordillera, where heavy rains each year make it necessary to have a dry-weather and a wet-weather trail. The wet-weather trail follows high ground and has a roundabout and longer course and steep gradients. It might be called an emergency trail and in most cases is abandoned as soon as a road of any pretensions has been built with bridges or improved fords that enable the graded valley trail to be used practically the whole year round.

I have spoken of the lower edge of the belt of grass that lies like a band across the western face of the mountains. It has also an upper edge where the short and nutritious grasses give way to the bunch grass, or *ichu* grass as it is called, and ground mosses and resinous shrubs such as the *tola* bush. The grass is in the temperate zone of the mountain flank; the mosses and resinous shrubs are in the alpine zone. High up on the plateau summits at 13,000 feet we were surprised to find the large and straight-stemmed cactus (*cardón*) where there are nightly frosts for at least six weeks of the year during late May, June, and early July. This general type of cactus is known in our Southwest but cannot endure frost there. The belt of grass between 8000 feet and 10,000 feet extends all the way from Peru, where I crossed it in 1911 on the 73rd meridian, southward



FIG. 6



FIG. 7



FIG. 8

FIG. 6—An *apacheta* made of stones thrown into place by passing llama drivers on the trail between Bolivia and Chile near the southern end of the Cordillera Silillica, elevation 14,200 feet.

FIG. 7—Wooden cross at the summit of the desert plain east of Paita, Peru, in a situation similar to that occupied by the *apachetas* of the Indians.

FIG. 8—An *apacheta* built of stones and adobe and serving as a shrine in which coca leaves, pieces of candle, and bits of llama wool were found on the trail between Pastos Grandes and Salar de Rincon (See Fig. 87).

along the mountain flanks into central Chile. On page 246 I have described its appearance and altitude in the neighborhood of San Pedro de Atacama and Soncor where we crossed it again in 1913. It is a feature of the mountains that has all sorts of interesting effects upon the local life, fixing the position of many mountain trails and determining the summer pasturing grounds of the mountain Indians. This last feature is more and more highly developed as we go southward, for the winters of the mountains on the southern edge of Atacama are progressively more severe, and the grazing folk can use the mountain pastures for a part of the year only.

The last part of the ascent to the summit of the westernmost plateau-like block of the Andes steepens, and the trail follows now the rocky interfluvium, all sand having been blown away, and now a steep-walled quebrada or ravine with a bouldery floor. With increasing altitude (to 14,000 feet) the going in the steepening trail becomes more and more arduous, and it is with a keen sense of appreciation that one sees the *signo del camino*, or pile of stones that marks the summit. Each traveler adds a stone for good luck, and thus in the course of generations the pile has grown to the dimensions shown in Figure 6. The feature is encountered in many places in different forms. Sometimes it is a cross, sometimes a pretentious structure serving as a shrine (Figs. 7 and 8).

After crossing the Altos de Pica, a broad plateau of erosion now uplifted to the great height of 14,000 feet and partly covered with an overflow of lava, we dropped down a steep trail toward Lake Huasco and made camp beside the spring at the western edge of the basin. There was plenty of tola about, and with this and the droppings of the llamas that had been herded in a stone corral at the camp site we made a campfire and spent a comfortable night except for the effects of the altitude. I had first felt its effects at 10,000 feet, but they wore off quickly; whereas my companion, Mr. Rogers, felt them not at all until we had reached 13,000 feet when he became alarmingly ill. The next morning he was about as usual and had almost no return of the symptoms during the rest of the journey.

THE HUASCO BASIN

The next day we rested our beasts at Lake Huasco, and with one of the guides I crossed over to the other side of the basin about twelve miles distant to study the volcanoes there and also to skirt its southern edge, where old shore lines were clearly visible. The so-called "lake" that now occupies but a portion of the salt-encrusted floor is but the shrunken remnant of a once large and deep lake that filled the whole depression. On the return in the late afternoon we rode through a broad patch of alluvium that was invested with vizcacha. The holes of these beasts honeycombed the soil, and our mules repeatedly stumbled and fell. I was frequently to encounter such colonies all the way through the mountains from central Peru to northwestern Argentina. On a winter's morning the holes are marked by a fringe of hoarfrost. Sometimes one may hear the vizcacha chattering to each other beyond the turn of a canyon wall and surprise them in a small group, but except in the most remote localities they dodge out of sight so quickly that all that one can make out is the merest flash of fur. Their skins are of little or no value, although many attempts have been made to market them. They are near relatives of the rarer chinchilla.

The trail from Huasco eastward climbs the long piedmont slope that stretches forward from the Cordillera Sillilica, crossing over the pass at the southern end whence a good view of the peaks of this volcanic chain fills the northern horizon. They are young volcanic cones with a plentiful snow cover in winter. We passed there in late May, which is the beginning of the southern winter, and though they appeared to have permanent snow fields, especially on Mt. Lorima, I was too far away to make sure of this.

In Peru practically all of the mountain basins have exits through which they discharge to lower levels. This is true of the smaller basins like Anta and Cuzco as well as the largest of all, Titicaca. In northern Chile, western and southwestern Bolivia, and northwestern Argentina, on the contrary, the basins are mostly self-contained and have no exits. It was a great satisfaction to cross the Chilean cordillera into Bolivia

in the latitude in which this change occurs. The Sililica trail hits both Lake Huasco, as I have described, and also a group of smaller basins between it and the central salt pan of western Bolivia at Llica. Huasco was at one time filled with water almost to the point of overflowing; and one after another of the neighboring mountain basins had the same fate in the Ice Age, when a wetter climate turned these now shallow grass-bordered evaporating pans into deep lakes filled almost to their brims.

MOUNTAIN SETTLEMENTS

After three uneventful days of journeying across the high mountain belt in which we passed only a few tiny settlements of a few huts each (a principal one is called Cueva Negra), we arrived at Llica on the eastern edge of the mountains in Bolivia (12,000 feet). We entered the town late at night after riding into a bitter wind that blew off the cold salars lying just east of the village. The mules floundered in the morass at the edge of the salar that here skirts the mountain border, and we should have had a cheerless camp indeed but for the happy coming of a Bolivian shepherd who had returned from his mountain camp in time to guide us by a narrow course to the end of the principal street of the village. The place was quite dark, not a single light showing anywhere. The clatter of our pack train awoke dogs and villagers, for the coming of a stranger after nightfall is a most unusual event in this remote place. At length we reached a sort of public place where we obtained lodging in a small room that had first been cleared of pigs and chickens and then swept. Tea and eggs and such bread, hard as a rock, as we had carried from Lagunas in the nitrate desert formed our supper. The next day we rode north along the shore line that here stands out prominently along the mountain side and out over the salar a short distance to study the composition of its surface. Then we talked with the single merchant of the town about the llama caravans and pack trains that come here, the source of food—the life here is almost exclusively pastoral—and the ways of the mountain folk who live in these secluded valleys.

Although all of the plateau and mountain people are shy, those of western Bolivia on the edge of the cordillera are quite remarkably timid and suspicious, as we discovered the next day when we rode out of Llica southward along the edge of the mountains. A bold wall of lava here overlooks the salt basins. The floors of the little valleys that have been cut in the border of the mountain country are the sites of tiny settlements. On the first day we passed Canquilla. The village appeared completely deserted as we approached it at midday. Almost at the outskirts of Suisigua, where we camped for the night, we saw a girl with a water jar on her head. She stood stock still at the sight of us and then disappeared. When we came to the top of the next rise we saw her running at top speed back to the village. We rode on into the town, past barred houses, without a sign of life until at last we reached an open door where our rapping brought out a very old woman who said at once and almost automatically "No hay" (there is none) to every question we asked about food for ourselves and forage for the beasts. Seeing a pile of green barley in a corral we helped ourselves to it with the thought of compensating the owner when he appeared. Darkness came on, and still there was no sign of life, neither voices nor lights. We had just prepared for bed when we were startled by a squeaky voice at the corral gate, and our guide came to tell us that the owner of the barley wanted to know if it was our intention to pay for it. We told him that we would pay him well if he also brought us eggs. When he returned we paid him and had him back the next morning to tell us where the next camp site could be found.

The next night we reached Laqueca. The village lies in an eastward-facing hollow where there is a stream to irrigate the green barley fields and supply the water jars of the houses. It is but a cluster of mud huts each a single story in height, with the customary grass thatch and windowless walls. The streets, if one may call them such, are narrow and unpaved. It is the home of a group of families that almost never see a white man pass. It was the same at Canquilla the day before. There are thirty or forty huts at Laqueca that appear quite deserted. We eventually found one old man and two children, but we

could not get near the latter who kept peeping out at us from behind the corners of huts. All the rest of the villagers were scattered about the hillsides herding llamas and sheep or gathering and threshing their crop of barley and quinoa, for this was the harvest season.

The prices one must pay in such tiny settlements vary with the year and the locality. One place may have a scarcity of forage and charge more for green barley and eggs than we should have to pay in New York City. Bargaining is absolutely necessary, but at best we were able to get eggs only by paying 20 cents Bolivian money, or 5 cents gold, apiece. At Llica our repeated requests for eggs brought out the information that the last of them had been sold the day before to a stranger who had come from Oruro and that it would be days before the supply would be replenished. Our bill at Llica for two nights and the intervening day carried no charge for the room we occupied but only for the food and candles and firewood we had consumed, because a room can be made of mud and lasts a lifetime, but food and candles are rare and costly.

Unlike the tributary villages with their shy folk the village of Llica is comparatively cosmopolitan. It has upwards of 200 houses. All roofs are neatly thatched, and the streets are exceptionally clean. A single store, kept by a Bolivian, is a meeting place for thick-tongued Indians who guzzle brandy and buy small supplies of bread, candles, and barley. The town is the meeting place of the trails that run along the eastern foot of the mountains or connect the mountain border settlements and also those that cross the Western Cordillera. They are followed by Indian traders who carry wool, firewood, blankets, and the like all the way from western Bolivia across the lofty mountains to the desert settlements along the foot of the Andes, where they exchange them for cotton cloth for undergarments and general use and for alcohol which they smuggle in without paying duty since the trade is too small to maintain the charge of customs stations. They walk great distances without food. Our mountain guide walked fifty miles without stopping for food, chewing coca all the time and keeping up with the mules without difficulty.

It is only after winning the confidence of the mountain Indians hereabout that one is able to get them to speak Spanish. From our "host" at Suisigua we learned that the harvest season was on. The native "grain," quinoa, was being threshed by tramping and winnowed by pitching it into the wind. In a few favored spots barley will ripen. Much of it is cut green for forage, and that which matures is used for soup and carried off to Llica or elsewhere for sale. Fifteen or twenty alluvial fans at the base of the surrounding hills are covered with little farms. The grains of barley and quinoa are planted in tiny holes several inches below the surface in order the better to get moisture, that which seeps down the mountain side and that which comes by way of the narrow and tiny irrigating ditch. The grain is pulled up by the roots; whether because that is the easier way or to prevent waste we could not discover. There was the most unusual excitement in contrast to the dead village we had seen the night before. Children were running about, almost as noisy as children elsewhere except when we rode up to the threshing scene. Herds of llamas and sheep were grazing on the dry and barren mountain sides, and here and there rose a column of smoke from a pile of burning straw. Though I had to stop for breath every few minutes, the people who lived here seemed to mind it not at all; and children and adults walked with a long free stride and even ran about or shouted to each other as if they were not living more than two miles and a half above sea level.

A LOST TRAIL

From Suisigua our course was southward past Laqueca. We had planned to go to the end of the Salar de Empexa and thence by way of the Salar de Coposa to the head of the canyon of the Huatacondo. The first day's journey led along the edge of salt basins or along perfectly dry stream beds over the low divides between adjacent basins. The "trail" consisted of a llama track which became less distinct toward nightfall and at last disappeared altogether. We made a dry camp at the edge of the Salar de Empexa, and there the mules consumed

the last of the green barley we had carried from Suisigua. We had carried an extra water supply for ourselves and left over until the next day a flask apiece for ourselves and the guides. Though there were many signs of water action all about, there was as little available water as in the nitrate desert. We had expected to find it everywhere in the high mountain country; but it was early winter, and winter is the dry season in the mountains. Doubtless the alluvium held sweet water, but there was little of it after the first day. Most of the streams west of the line of salars have rock floors or run over a thin layer of coarse rock débris. We could return to Laqueca and on the morning of the second day anxiously discussed this possibility. The guides had inquired of the llama herders at Laqueca and Suisigua as to the condition of the trail along the Salar de Empexa and were told that only bitter waters could be found. They advised taking a westward-bearing trail, and this we did. Although we traveled through high and broken country all day, we again passed not even a trickle of water except in the early morning. Through a belt of variegated copper-bearing rock, where we saw signs of prospecting at an earlier time, there ran a tiny stream; but it was so salty that we could drink none of it, and the mules but little. At sight of every ravine we confidently expected water only to be disappointed, and at nightfall we were in a worse situation than before. Our water flasks were now quite empty, and we were suffering from thirst. It was useless to prepare food. The mules refused to eat the dry barley that we had carried from the start for an emergency. The guides came to our tent and mournfully confessed that they were hopelessly lost. Our camp was under the lee of a rock cliff, and our dejected mules were tied to the tola bushes that grew on the floor of the ravine below us.

All day the sky had been overcast, and this added to the anxiety of the guides who feared that we should be caught in a snowstorm. Yet in fact this ended our anxiety; for after midnight snow began to fall, and we immediately melted a kettle of it and had tea and biscuits all round. By daybreak several inches of snow had fallen, and the trails were completely hid-



FIG. 9



FIG. 10

FIG. 9—Dissected volcanic country at the eastern border of the Western Andes, a day's journey (about 25 miles) southwest of Llica, Bolivia.

FIG. 10—A typical sand-choked valley with a wild growth of shrubs and grasses at the piedmont border (below the oasis of Soncor, near San Pedro de Atacama).

den. Even the landmarks of the day before were so unfamiliar to us that we had little hope of returning along the route over which we had come. Thereafter we went west through a maze of ravines and volcanoes thoroughly covered with snow that fell almost without interruption until after dark. While there was still a little light we descended into a basin which I instantly recognized as that of Huasco which we had crossed the week before. The guides, Lindor and Pedro, insisted that we were a hundred miles farther south. In searching for a settlement that he was sure he could find in a half hour, Lindor encouraged us by calling out again and again that he was crossing a trail and that the village must be near. After nearly an hour of this I inspected the trail with a flashlight and found that it was our own and that we were crossing and recrossing it by circling around toward the left. We had ridden all day with a wind blowing from the left, and when it stopped we bore off in that direction. The next morning the pattern of our trails was spread over a half mile of snow beyond our tent.

We camped in the snow again without supper quite overcome with fatigue from the steady roar of the wind in our ears all day long and the heavy walking we had done in the snow at the high altitude to relieve our famished mules. The following morning we found a spring a mile or more away at the southern edge of the basin and there filled our water flasks and watered our beasts. All that day we floundered in snow, making a southward course. Though the morning had been clear and cold, snow now fell occasionally, and the wind drifted that which had already fallen. By mid-afternoon the going was not only extremely difficult but unsafe, yet we were obliged to keep on and get below the snow line if possible. In spite of our difficult situation we stopped for a half hour at the end of the day to admire the most remarkable display of sunset colors that I have ever seen.

We descended into the steep head of a shallow ravine and got below the snow cover with the last of the daylight. An hour farther on and we found a turn in the ravine where there was at least a little shelter from the bitter down-valley wind and made there our fourth dry camp and went supperless to

sleep. Lindor had fallen off his mule before we could reach him when the pack train stopped. There was still one long and hard day before we could hope to get to pasture and water. The next day's trail led across a series of ravines that seemed endless. By midday we reached the head of the Chacarilla canyon and tried to go directly down over the talus slopes; but the boulders were so huge, and the going so perilous for the



FIG. 11—Wind-rippled sand dune on the border of the Salar de Atacama, near Soncor. Compare with Figure 4, page 17. See Figure 1 for location.

mules, that we climbed again to the rim and continued the wearisome process of skirting the entire border of the huge amphitheater that forms the head of the canyon. What made the process particularly tantalizing was the sight of green pasture and a pool of water at the foot of the gorge wall. But the thousand feet of descent was more difficult than the miles of circuit we were making to the springs of Caya.

THE OASIS OF CAYA

The oasis of Caya has an elevation of 11,500 feet. It is merely a camp site, not a place of settlement. In this respect it is like a number of other places indicated upon the Iquique sheet of the American Geographical Society's Millionth Map

of Hispanic America. Grass and water are to be had at marshy spots at the foot of headwater scarps, and every one of these green patches is known to men who follow the trails. As the contours on the Iquique sheet plainly show, there is a flat tabular element in the relief of the crest of the cordillera that continues all the way from the Cordillera Sillilica, a little south of latitude 20° S., southward through the entire sheet and even into the Atacama sheet beyond. These flat tabular masses are separated by very deep and steep-sided ravines and canyons, which are completely hidden if one stands upon the summit of one of the plateau-like tracts and looks lengthwise along the range. So conspicuous are the tabular masses and so different from the general character of the peaks east of them that form clusters and ranges upon the watershed that they have been given specific names. For example on the northern border of the Iquique sheet in longitude 69° and almost due east of Iquique are the "Altos de Sitalca," south of them the "Altos de Pica," both of which exceed 4000 meters (13,000 feet) in elevation. South of Calama are similar masses, most of which are called "cerros," the term being used not in the usual sense as indicating an isolated hill or hills but in the sense of elevated tracts of land crowned by isolated hills; and between these cerros are broad and rather flat high-level tracts whose borders are the gathering grounds of waste from the mountains, strewn in broad belts where the plain and the plateau meet. The latter are called "llanos." Examples appear upon the Iquique sheet (about latitude 23° S., longitude $68^{\circ} 30'$ W.) in the "Llano del Quimal" and the "Llano de la Paciencia." Between the Llano de la Paciencia and the Salar de Atacama there lies the Cerros de la Sal. The latter again illustrates the tabular character of a great deal of the relief that constitutes the western flank and summit of the Western Cordillera. Seen from the eastern side of the Salar de Atacama the Cerros de la Sal has a strikingly even sky line. I have photographed it over a horizontal distance of fifteen or twenty miles and crossed it on the trail to Calama, where its complicated structure and its even top are in marked discordance and indicate an old relief developed at a lower level

and now warped upward to form a part of the summit arch of the western part of the great Andean chain.

The pastures of Caya, to which I have referred, lie at the head of one of the deep canyons that cut across the tabular western portion of the cordillera from their sources in volcanoes and high volcanic masses to the eastward that form the crest line and watershed of the Western Cordillera of the Andes. The trail from Caya at first climbs up to the summit of a minor watershed, then passes over a knifelike ridge so narrow that there is room at the top merely for the foot-wide trail. At one point one can look down over the flank of one's riding mule a full 1000 feet to the foot of a precipice and steep talus that form a part of the canyon wall. The slightest misstep would precipitate beast and rider down this great precipice, and it can be a question of only a short time until the ridge itself is attacked by weathering agencies and a new trail must then be located. Farther down, the trail makes the steep descent of the valley or canyon by caracoles, or zigzags, and shortly after reaching the canyon floor leads to the oasis of Chacarilla. The settlement is on the northern side of the valley at a point where a small tributary stream comes down from the *altos*, or heights, and where the waters of the Quebrada de Chacarilla can be led out through irrigating canals to the gardens of the oasis dwellers. It is near the now abandoned copper mines of Victoria, which were for a time the scene of some mining interest. There were only a few people about at the time of our visit, and in all there could not have been more than forty or fifty separate habitations. From one of them a woman came running out to the edge of a terrace that overlooks the trail and inquired if we were Englishmen from the coast and if we were, if we had any condensed milk with us. Speaking in Spanish she told us that she had a very young baby and that her breasts had dried up and she was unable to feed it. When we told her regretfully that the last of our condensed milk had been used that morning and that we were practically without any food ourselves, she said, "Then if you have no milk my baby must die." The tragedy seemed to strike us more deeply than it did her, for she immediately

began to talk of other things and to inquire about our route and our destination as casually as she might under happier circumstances.

RETURN TO THE DESERT

After several weeks in the mountains and highlands at great elevations and with freezing temperatures at night, we found the soft, balmy air that swept up the canyon from the desert an immense relief, and our spirits returned with every foot of descent. We sang and shouted like boys out of school and peeled off one layer after another of clothing as the air grew warmer and warmer. The only source of discomfort was in cracked and chapped hands and faces. Every exposed portion of our necks and heads was covered with a scabby crust, the result of glare from the snow and the drying effect of the high winds we had experienced.

A shrubby vegetation now began to come in and increased in height until nightfall, at Algarrobal, at an elevation of about 6000 feet we camped in the midst of a small scattered grove of algarrobo trees. Here we saw signs of terracing and of irrigating canals that had been constructed years before but abandoned since an unusually destructive flood had devastated the site. Our mules found at least scant pasture, and we ourselves had a comfortable night's rest for the first time since we had left Pica several weeks before. Our food boxes contained nothing but a little oatmeal, which we were almost unable to eat, and some sweet crackers which we could not eat at all; but eating of any sort was almost out of the question, for as we came down to lower elevations our thirst increased to such an extent that we could do without water for hardly more than fifteen minutes at a stretch.

From Algarrobal we set out the following morning and by a little after midday had reached Pique, where there are wells and shade trees. It is a pumping station for the nitrate works of Alianza farther west. After we had rested our beasts and ourselves, and the sun had declined to the point where the desert heat and glare on the salt-incrusted surface were no longer unendurable, we started with our pack train westward



FIG. 12



FIG. 13

FIG. 12—The oasis of Monte la Soledad dependent upon a single well.

FIG. 13—Alfalfa pastures at Calama in the Loa valley, with the Andes as a background.

over the Salar de Bella Vista to the nitrate establishment of Alianza, arriving long after dark and glad to accept the hospitality of the nitrate officials there. No welcome could be more cordial than that which these Englishmen gave us, and they instantly telephoned word of our arrival to the nitrate *oficina* at Lagunas. They had heard the day before that we had overstayed our period of exploration in the mountains, and great anxiety was felt partly on this account and because of our limited food supply and partly on account of the heavy snows that had blanketed the mountains for days and in which they knew we must surely have been caught. It had been planned to organize several searching parties to set out the following day by different routes into the mountains. From Alianza we went by train to Lagunas the following day, our pack train going down under the care of the guides. As a result of the effects of the altitude and of the change in the quality of the water, and of our excessive use of the desert water when we first came down, we were ill for a week at Lagunas.

As soon as we were able to manage it we started out again southward through the desert. Our first day's journey was from Lagunas seventy-five miles by trail southward by way of Monte la Soledad and the Pampa del Tamarugal to Quillagua, in the Loa valley. This course is now covered by a railway, but at that time it was virgin desert with no sign of habitation in that entire stretch except a cluster of huts at Monte la Soledad (Fig. 12), where lived a family of three—father, mother, and son—maintaining themselves by means of a single well and a mixed flock of goats and sheep supplemented by a few riding mules and fowl. It was the smallest and the most isolated settlement that I have ever seen in the desert, but it was once a little larger, the rest of the inhabitants having gone to work in the nitrate fields. By contrast, Quillagua in the Loa valley is in a broad, fertile, terraced valley; and, although the Loa River is notorious for its content of salt, the inhabitants manage to irrigate their fields from it and from a few bordering brooks, springs, and seepage lines and thus to maintain what is by contrast to most desert settlements a prosperous-looking community of farmers and shep-

herds. Trees from forty to fifty feet high may be seen here, and there are expanses of marshy ground too salty to allow a good growth of alfalfa but with sufficient pasture to attract herds for a part of the year (Fig. 13).

From Quillagua our course lay up the valley side and to the desert again, to the nitrate establishments on the border of the valley. The river has been dammed, and electrical works have been installed to furnish power for the nitrate works at Santa Fé. The cost of the installation was large, but the very high price of imported coal induced the use of water power; and the nitrate works were said to enjoy a great advantage over neighboring establishments situated in the midst of the desert and far from any natural source of power. Our host took us to his gardens in the Loa valley where he had a lodge which he frequented on Sundays and holidays—a charming embowered spot doubly precious by reason of the waste of salt and sand of the surrounding desert.

CHAPTER III

RAINFALL OF THE DESERT

The coast of northern Chile is quite the driest of which there is any record in the world. For a 21-year period Iquique has an average rainfall of 1.5 mm. (0.6 inch), and Arica (for a 19-year period) has still less, 0.6 mm. But an average in the desert is as nearly useless a computation as even the desert affords. There is no such thing as a normal desert rainfall. Years of absolute drought pass, and the foreigner who comes out on a three-year or five-year contract may stay his time and depart without having known a drop of rain to fall; and he may even assert that it never falls and speak as one who knows because he "has lived there." The British Consul at Iquique told me that he had advised some of his friends who were coming out from England not to bring umbrellas, for in the fourteen years that he had then known the coast no rain had fallen. Yet on the night on which they disembarked from the steamer it was raining hard. In 1906 there was a three days' rain, a succession of light showers with intervals of heavy mist, which penetrated the houses and collected and ran off walls and ceilings and soaked the carpets and beds. It is only the rare downpour that gives Iquique anything at all to average through the years. It is as nearly like a rainless land as any that we know on the earth today.

EXCEPTIONAL RAINS AND FLOODS IN THE NITRATE DESERT

Yet it must be impressed that rains actually do occur at intervals in the Desert of Atacama and that some of them are of extraordinary character. The reason for their occurrence is not quite clear. In the Cordillera of the Andes and the western foothills periodic summer rains fall as far down as 8000 or 10,000 feet, lower still in some places, higher up in others. At long intervals the usual rains may be supplemented by an extraordinarily heavy snowfall or an equally heavy rainfall. The sudden precipitation of rain in unusual quantities is a

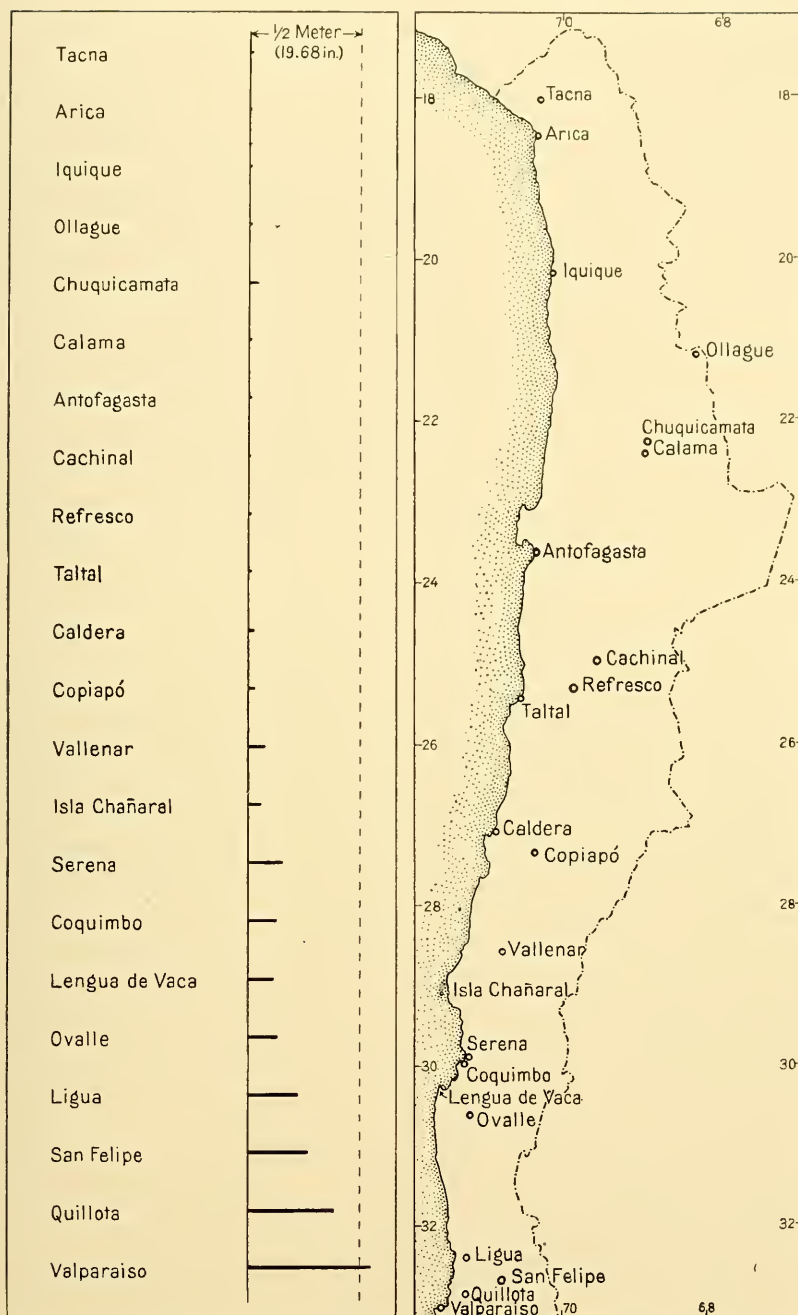


FIG. 14—Diagram (and location map) to illustrate the rainfall of the Desert of Atacama and the transition zone to the south. (From *Recopilación de sumas de agua caída en Chile 1849-1915*, *Inst. Meteorol. y Geofísico de Chile, Sección Lluvias*, Publ. No. 20, Santiago, 1917.)

feature of practically all the deserts in the world. In northern Chile the rains and snows produce heavy floods that extend far out over the nitrate pampa and freshen the innumerable gullies that feed the main streams and spread vast sheets of mud and gravel over the outer piedmont. They are said to occur once or twice in a lifetime.¹⁰ Billinghamurst notes nineteenth century floods in the Pampa del Tamarugal in 1819, 1823, 1852, 1859, 1878, and 1884.¹¹ Bollaert comments on those of 1819 and 1852.¹² Floods also occurred here in 1903 and 1911. Probably some of the storms are quite local in character, but others appear to be associated with widespread periods of rain, as those of 1819 and 1911. The latter was a season of extraordinary character. Fortunately we have an official meteorological record of it.¹³ The phenomena recorded are so unusual in this region that it is worth while to reproduce the report in some detail.

THE RAINS OF 1911

On February 15 and 16, 1911, the towns of Pozo Almonte, Huara, Pisagua, and others of the province of Tarapacá suffered a great inundation following days of furious snowstorms in the cordillera. Increase in the river at Tacna interrupted communication between that town and Arica; an enormous lake that formed between Huara and Pozo Almonte suspended railroad service there; the work of the *salitreras* was paralyzed, numerous workmen's encampments were destroyed, and likewise a large quantity of nitrate. In some parts of the pampa it rained copiously on the night of the 13th, though elsewhere not a drop fell. On June 24 of the same year rain fell at Antofagasta in the early morning; it was accompanied with a violent thunderstorm that caused great alarm among the people, so rare is such a phenomenon on the coast. At 3 P. M.

¹⁰ F. J. San Roman: *Desierto i Cordilleras de Atacama*, 2 vols., Santiago, 1896; reference in Vol. I, pp. 190-191.

¹¹ G. E. Billinghamurst: *Estudio sobre la geografía de Tarapacá*, Santiago, 1886, p. 36.

¹² William Bollaert: *Antiquarian, Ethnological and Other Researches in New Granada, Ecuador, Peru and Chile*, London, 1860, p. 263.

¹³ *Anuario Meteorológico de Chile 1911*, Inst. Central Meteorol. y Geofísico, Santiago, 1912.

the storm subsided although rain still continued to fall. In Calama (altitude 7400 feet, latitude 23° S.) the streets and houses were covered with a thick layer of snow. In Iquique the phenomenon began with a light *garúa* (mist) at 10 P. M. followed by a northeast wind that attained hurricane velocity before it subsided at 2 A. M. with a sudden drop of temperature. In Tacna on the night of the 23rd a hot wind from the cordillera accompanied with rain and hail blew (with an interruption at 2 A. M.) until daybreak and was repeated on the following day. Telegraphic communication between Tacna and Arica was interrupted, and many trees were blown down in the plantations and gardens. A few days previously weather of a similar description had been encountered on the Peruvian coast. The disturbance was felt at Copiapó, Serena, and Coquimbo, so that altogether it extended over 20° of latitude, being propagated from north to south.

The same year heavy snows were reported even from the driest zone of the cordillera. In the mountains above San Pedro de Atacama snow was 10 feet deep, and in San Pedro itself (8000 feet) snow fell from July 22 to July 26 and again from July 30 to August 1, the snow being 8–10 inches deep, a phenomenon never before seen in the town nor known in tradition. People came from afar to see the wonderful spectacle; excursions were run from Antofagasta. Naturally the storm was accompanied by disaster to travelers and herdsmen of the cordillera. Two hundred head of cattle were lost, and several persons including a number of chinchilla hunters perished. Previous heavy precipitation had occurred in January and February of 1885, i. e. in the year succeeding notable floods in the Pampa del Tamarugal. In those months were 40 days of rain; rain falling every day from 1 to 7 P. M.

THE SOUTHERN MARGIN OF THE DESERT

Going southward through the Desert of Atacama another climatic province is entered about the latitude of Copiapó.¹⁴

¹⁴ On the rainfall regions of Chile see Mark Jefferson: *The Rainfall of Chile*, *Amer. Geogr. Soc. Research Series No. 7*, New York, 1921.

DESERT TRAILS OF ATACAMA

TABLE I—DATES OF RAINFALL AND QUANTITY OF WATER, 1888-1913
(In millimeters)

			Total for Year				Total for Year
1888	30 April.....	9.5	66.9	1902	28 June.....	3.8	59.0
	8 August.....	6.5			10 July.....	54.4	
13, 14	August.....	36.8			28 July.....	0.8	
20	October.....	14.1					
1889	2 April.....	0.3	4.5	1903	2 May.....	1.8	14.1
	8 May.....	3.6			2 June.....	0.2	
	17 August.....	0.6			18 June.....	0.1	
					27 July.....	12.0	
1890	14 June.....	21.5	33.5	1904	22 May.....	1.1	49.0
	3 July.....	12.0			13 June.....	0.6	
					27 June.....	3.3	
					10 July.....	2.7	
1891	21 July.....	2.6	7.8		16 July.....	20.6	51.3
	28 August.....	5.2			30 July.....	13.2	
					29 August.....	3.3	
					20 October.....	4.2	
1892			0.0				51.3
1893			0.0	1905	23 April.....	0.3	
1894	20 July.....	26.1	37.8		24 April.....	0.2	
	30 July.....	0.5			30 May.....	5.8	
	12 August.....	11.2			14 July.....	18.2	
					30 July.....	13.8	
1895			0.0		18 August.....	13.0	5.9
1896			0.0	1906	20 May.....	2.1	
1897	25 May.....	13.4	45.0		3 June.....	3.8	
	19 June.....	31.6					
				1907	4 May.....	2.4	5.2
					21 May.....	2.8	
1898	23 May.....	10.4	19.9				
	26 June.....	0.45		1908	29 June.....	2.0	
	27 June.....	9.05		1909	8 May.....	4.4	22.3
					4 June.....	4.4	
1899	3 July.....	20.7	31.35		16, 17 June.....	13.5	
	8 August.....	7.6		1910			
	11 August.....	0.7		1911	13 May.....	11.4	13.4
	19 August.....	2.35			25 June.....	0.0	
1900	27 April.....	14.5	86.5		31 July.....	2.0	
	18 July.....	23.5					
	19 July.....	1.0		1912			0.0
	21 August.....	42.0		1913			0.0
	29 August.....	4.2	8.2				21.7
	18 November....	1.3		1888-1913 Average.....			
1901	2 July.....	5.4					
	2 August.....	2.8					

Rainfall increases in frequency and amount. The average rainfall of Copiapó may be given as about 20 mm. The average for the 26 year period 1888-1913 was 22 mm.¹⁵ I copied the records of the Meteorological Observatory of Copiapó for this period and give them in Table I.

East of the Copiapó valley the rainfall increases with elevation on the western flank of the Andes. Bordering the valley are the outer ranges of the cordillera, which in summer have heavier rainfall than the lower desert and which occasionally have snow in the winter season. The effect is clearly seen in the vegetation and belts of settlement. The desert sands and bare rock surfaces or pebble pavements (Figs. 4, 5, and 15) give way to grass-covered tracts where the mountain streams debouch (Fig. 16); and higher up are the *pajonales* where bunch grass and shrubs and a thin scattered growth of succulent grasses come in after the summer rains (Fig. 17). Each important stream has its clump of huts, and the largest streams are marked by villages or towns no matter how remote the situation may be. Each pasture tract is annually invaded and explored by the migratory shepherds in the summer season.

In addition, there is a heavy belt of fog which during most of the year hangs on the western slope of the Coast Range and even extends inland, so that a certain amount of moisture is collected mechanically from the fog and furnishes additional moisture for lowly desert shrubs and grasses. South of Copiapó the rains increase in number, and the rainfall increases in amount per shower as well, so that in the one hundred miles from Copiapó to Vallenar the rainfall has increased to 80 mm. a year. The latter place has at least twice as many showers and four times as much rain as the former.

Even in the northern section of this transition zone, between Copiapó and Huasco, it is unusual to find two successive years *absolutely* rainless, although there may be a period of six or seven years with very little rain; but it must be impressed that

¹⁵ As already indicated widely different "averages" will be obtained for desert rainfalls according to the observation period. The official figure for the average rainfall of Copiapó for 23 years between 1870 and 1915 is 17.8 mm. (Recopilación de sumas de agua caída en Chile 1849-1915, *Inst. Meteorol. y Geofísico de Chile, Sección Lluvias, Publ. No. 20*, Santiago, 1917.)



FIG. 15



FIG. 16



FIG. 17

FIG. 15—On the hot sandy trail between Socaire and San Pedro de Atacama.

FIG. 16—Tambillo, a camp site on the grassy border of the Salar de Atacama near San Pedro de Atacama.

FIG. 17—El Totoral, the name given to the belt of shrub and grass on the long western slope of the main chain of the Andes east of Socaire and Soncor. The crest of the main chain, here formed of steep-sided volcanoes, appears in the background.

“much” and “little” with reference to rainfall are here purely relative terms.

The rainy season of Copiapó extends from May to August, with occasional rains as early as April and as late as October; but the rain is limited to individual showers: the average number of rainy days a year in the period 1888–1913 was between three and four. The heaviest individual rainfalls were 36.8 mm. (1.4 inches) on August 13 and 14, 1888; 54.4 mm. (2.1 inches) on July 10, 1902; 42 mm. (1.6 inches) on August 21, 1900. Such heavy rainfalls result in flood. Floods, too, originate in the still heavier storms of the cordillera.

DESERT DRAINAGE TYPES

Floods are not unknown in the nitrate region, as we noted on an earlier page, but they are of short duration and quite infrequent even though the greatest of them are known to have covered vast stretches of the nitrate pampa. Such floods are of unusual occurrence because they require unusual snowfall in the mountains combined with very rapid melting, and these two circumstances are rarely brought about in the same season. South of the nitrate desert, as in the mountain region east of Copiapó, not only the rains but the snows are much more frequent, hence also the chance of floods. Here the combination of rain and melting snow may greatly augment the stream flow. Whereas only about one cubic meter a second was flowing in the natural channel of the Copiapó River when I saw it in July, 1913, it has been known to increase to 100 cubic meters a second, as in 1888 when 1.4 inches of rain fell at one time. Added to this we have a very interesting physiographic condition which heightens the floods and increases the risks of the valley dwellers who depend upon a mountain stream to furnish life to their fields and gardens—the great convergence of headwater streams in the mountains. A drainage map of almost any desert region shows a system curiously disorganized and without plan save as a few radial lines of streams focus upon a given desert basin (Fig. 18). At intervals one basin may be found draining into another, and at still rarer

intervals it may be that a large through-flowing stream may collect the drainage of a string of basins and minor valleys. If the rainfall increases in amount there is a corresponding in-

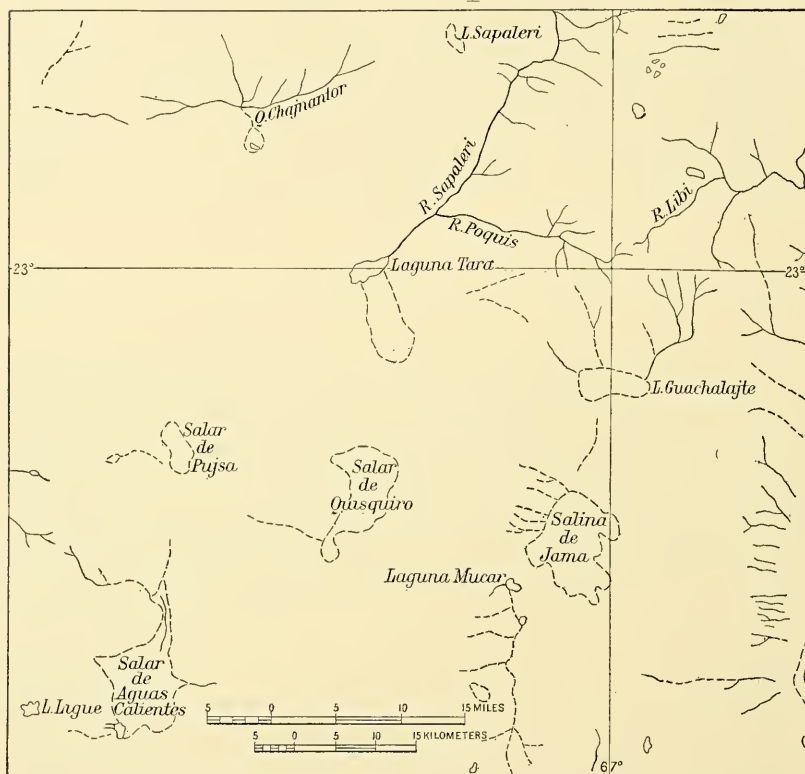


FIG. 18—Interior-basin types of drainage features upon the high and cold Puna de Atacama and other arid or semi-arid plateau-and-mountain regions adjacent. Short disconnected drainage systems are the rule, with intermittent streams and salt-covered basin floors. See Fig. 1, p. 10, for the general geographical setting.

crease of stream organization. The individual basins are no longer isolated and self-contained but receive the water and waste of tributary streams upon their floors, while the self-contained basin has a salt lake or a salt-incrusted floor with wide marginal flats. In the season of rain the floors of the connected basins are generally drained by incised streams that are rapidly cutting their way downward in the general process

of the denudation of the land. The Copiapó region is marked by the latter type of desert valley and basin: i. e. the streams collect the run-off over a great extent of territory and by converging it in one main valley subject the people now to great floods and again to long periods of extreme low water according as there are floods and droughts in the head-water region. Were a still greater desert drainage to be gathered together the extremes of water level would be still greater, although there is at least one corresponding advantage—there is some water in all years. Salt incrustations are not infrequent in the Copiapó valley, but they are only a few inches thick at most. Where water stagnates and evaporates a salt deposit gathers, and this renders irrigation the more difficult in certain places. Thus we have here near the border of the westerlies a type of drainage distinct from (1) that in the still drier north where the mountain streams terminate on the land, and (2) that in the wetter south, where the streams always reach the sea.

PRECIPITATION IN RELATION TO CULTIVATION

The people of Copiapó and Vallenar are accustomed to seeing black clouds in the sky and no rain, a white blanket of snow in the cordillera and none upon the nearer hills, heavy fogs and some rain upon the coast and occasional fogs and only a few light showers a year in the valley. They take these things as a matter of course, but to one who is studying such an environment in the field or to the newcomer who thinks of what all that distant water would do if turned out upon the irrigable land in the valley, it seems an extraordinary handicap. But it is not where rain falls, it is where it can be put to best use, that determines the site of a desert settlement. Our own connection with rain upon the cornfields and wheatfields of the Middle West is direct and immediate. A shower in one township benefits that township and not a neighboring one. In the desert the situation is quite different. Pastures spring up in regions of rain and snow, as in the cordillera and in the coastal hills; but for agriculture there is required irrigation, and this takes not merely water but also flat land upon which water can be diverted from irrigating canals.

One further observation upon water supply is necessary here to understand the nature of the climate and settlements of the Atacama region. Desert oases are of two general kinds: (1) those that lie on heights that reach into the zone of cloud and rain and (2) those that lie in hollows or valleys that have river water or ground water. Raton Mesa in New Mexico represents the first type; Copiapó and Vallenar the second—they lie deep down in the ground. So extremely dry is the Desert of Atacama that none of the heights in it, though they reach several thousand feet above the general level, catch a significant rainfall. The nearest approach to the high-island-like oasis of Raton Mesa is to be found along the coast of Chile, as at Paposo, south of Antofagasta, where the heavy fog supports a little herbage—the counterpart of the grassy hills of wet weather seasons along the so-called *lomas* of coastal Peru.

EFFECT OF A SINGLE SHOWER

The effect of a single shower on the southern margin of the Chilean desert (about Coquimbo) is noted by Darwin:

“ . . . The farmers, who plant corn near the seacoast where the atmosphere is more humid, taking advantage of this shower, would break up the ground; after a second they would put the seed in; and if a third shower should fall, they would reap a good harvest in the spring. It was interesting to watch the effect of this trifling amount of moisture. Twelve hours afterwards the ground appeared as dry as ever; yet after an interval of ten days, all the hills were faintly tinged with green patches; the grass being sparingly scattered in hair-like fibres a full inch in length. Before this shower every part of the surface was bare as on a high road.”¹⁶

Going still farther northward toward the Huasco valley, Darwin took the coast road, “which was considered rather less desert than the other.” The shower which he mentions above had reached (a fortnight before) about halfway to Huasco, and so far as it extended the ground was covered with a faint tinge

¹⁶ Charles Darwin: *Journal of Researches into the Natural History and Geology of the Countries Visited during the Voyage of H.M.S. Beagle round the World*, 2nd edit., London, 1860, p. 342.

of green. Even where this was brightest, "it was scarcely sufficient to remind one of the fresh turf and budding flowers of the spring of other countries." At Vallenar, a "green valley" bordered by "naked hills," he learned that a shower had not fallen for thirteen months. "The inhabitants heard with the greatest envy of the rain at Coquimbo; from the appearance of the sky they had hopes of equally good fortune, which, a fortnight afterwards, were realized. I was at Copiapó at the time; and there the people, with equal envy, talked of the abundant rain at Guasco. After two or three very dry years, perhaps with not more than one shower during the whole time, a rainy year generally follows; and this does more harm than even the drought. The rivers swell, and cover with gravel and sand the narrow strips of ground, which alone are fit for cultivation. The floods also injure the irrigating ditches. Great devastation had thus been caused three years ago."¹⁷

It is the greater frequency of rain that gives the hills of the Coast Range the moisture necessary for this vegetation (scant as it is) as we go southward from Antofagasta. These showers may seem of small consequence to us who live in a happier climate, but they are of immense concern to those who live on the edge of the habitable lands where the margin of safety is small or vanishes altogether.

FOG AND CLOUD ON THE COAST

To the traveler on the desert coast of Chile and Peru it is a source of constant surprise that the sky is so often overcast and the ports hidden by fog, while on every hand there are clear evidences of extreme aridity. The big desert tracts lie east of the Coast Range, and there, except for slight summer cloudiness, cloudless skies are the rule. The desert of the littoral is in many parts only a narrow fringe of dry marine terraces quite unlike the real desert beyond in type of weather and in resources. The fog bank overhanging it forms over the Humboldt Current and the upwelling cold water between the current and the shore, drifts landward with the onshore wind,

¹⁷ *Ibid.*, pp. 348-349.

and gathers on the seaward slopes of the coastal hills as the inflowing air ascends them in its journey eastward (see Fig. 19 for illustration of the general principles involved). Sometimes it lies as fog on the surface of the land and the water; more frequently it is cloud that hangs some distance above them. On many parts of the coast its characteristic position is

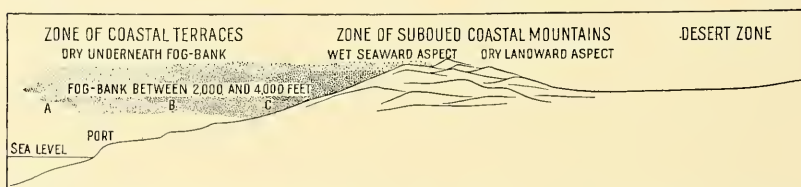


FIG. 19.—Topographic and climatic cross section to show varying positions (A, B, C) of the cloud bank on the seaward edge of the desert of northern Chile and Peru.

from 2000 to 4000 feet above sea level, descending at night nearly or quite to the surface, ascending by day and sometimes all but disappearing except as rain clouds on the hills. According to Mossman,¹⁸ the relative humidity on the coast between latitude 18° and 30° S. rarely falls below 50 per cent. At Iquique the monthly range is 74–77 per cent.

In Peru the coastal fog is known as *garúa*, in Chile as *camanchaca*. There is much variation from place to place in its position and habits. Lima, in latitude 12° S., has a great deal of fog; while Trujillo, in latitude 10° S., has little fog and a good deal of sunshine and is distinctly warmer. Fog is characteristic of Antofagasta during the winter season; by contrast it is largely absent at Iquique. Where the hills of the Coast Range are high or there is a convergence of slopes toward a central point the fog may thicken to an actual drizzle and determine the location of a settlement. Paposo, as we have already mentioned, has a little pasture supported chiefly by the coast fog.

Copiapó lies within (east of) the Coast Range, and, though its elevation is but 1300 feet above the sea, it enjoys a certain protection. On the coast at Caldera, the principal port of the

¹⁸ R. C. Mossman: The Climate of Chile, *Journ. Scottish Meteorol. Soc.* Ser. 3, Vol. 15, 1910, pp. 313–346; reference on p. 320.

valley of Copiapó, the fog hangs over the hills and the bay a good part of the time. In the sketch, Figure 19, the belt of fog is shown surmounting the coastal hills and reaching inland over the valley. It does not sweep up the valley, as it does in the small draws of the Coast Range that slope directly down to the Pacific, but settles down from aloft as night comes on, and in the morning the whole valley may be filled with it. It is indeed a strange experience to be in the midst of desert country, so far removed from the sea that there is neither sight nor sound of it, and yet awake in the morning to find the air filled with a clammy, cold fog. It does not long survive the morning sun, and after a few hours of daylight the edge of it may be seen retreating up the slopes to the crests of the coastal hills.

Riding northward through the coastal desert toward the Huasco valley Darwin in 1835 observed the belt of fog from elevated points along the trail and wrote: "During the winter months, both in northern Chile and in Peru, a uniform bank of clouds hangs, at no great height, over the Pacific. From the mountains we had a very striking view of this white and brilliant aerial-field, which sent arms up the valleys, leaving islands and promontories in the same manner, as the sea does in the Chonos archipelago and in Tierra del Fuego."¹⁹

As for distribution through the year there may be said to be a cloudy season and a cloudless season. The cloudless season comes in the southern summer from November to April, and the cloudy season in the southern winter from May to October. So far as the coast has rain directly or indirectly from the fog bank that hangs over its margin, it is a winter rain, more characteristic of subtropical than tropical lands. For the characteristic summer rains of the tropics one must cross the foggy coastal belt, continue across the coastal desert and enter the cordillera, where regular summer rains prevail at elevations that vary from 4000 to 10,000 feet according to the latitude. Over the whole Central Andes it is the rule that the southern summer (December to February) is the season of rain, the winter the season of comparative dryness.

¹⁹ Darwin, *op. cit.*, p. 348.

When the fog belt hangs high over the hills it is the season of dryness. When the fog belt thickens and extends from sea level to the summit of the hills rain may fall. The fog bank is thickest from June to September, and in that period the sun may be hidden for weeks at a time except for occasional glimpses through the fog or at sunset when it peeps from beneath the cloud cover before disappearing below the horizon.

There is a somewhat sympathetic relation between the dryness of a place and the duration of fog. The rainfall of the coast of southern Peru diminishes southward in a general way, and the driest part of the coast of Chile is from Arica to Caldera. Thence southward there is a slight but distinct increase in the rainfall. The southern end of the desert to a marked degree has rains which follow upon great atmospheric disturbances in the cordillera. South of Coquimbo this is particularly the case, and in that direction the fog bank on the coast diminishes in thickness, being of consequence only in the winter. The coast is here hidden by mist rather than the characteristic and pronounced fog of more northerly situations. From southern Peru 900 miles southward to the end of the Desert of Atacama in 32° S. the fog bank of the coast has little effect upon vegetation in spite of the greater height of the Coast Range. This condition of coastal dryness corresponds with the extreme aridity of the desert that lies between the coast ranges and the cordillera and is explained not by the relations of coastal scarp to cold sea, as on pages 51 and 52, but rather by the height and breadth of the mountain zone east of the nitrate desert and the general system of winds and rains that affect all places in this latitude. It must not be thought that this terrestrial wind system has anything more than a general expression at any given point on the earth's surface. The weather from day to day is the effect of local causes or agencies—a mountain, a regional wind from this or that quarter, a fog bank or the absence of it, a cloud belt. The variations in these things affect the hourly and daily changes of weather in a given place, but their range in turn is determined by their situation with respect to the great belts of wind and rain that in a general way control the weather

over broad tracts of land and sea. While we have a cold current along the entire west coast of South America as far north as Ecuador, and while the interplay between the cold current and the warm land has the general effect of causing a cloud bank to form over the coast, the position of the cloud bank, its density, whether or not it produces rain, are under at least the partial control of still greater forces relating to the broad outlines of the cordillera on the east and to the habits of the wind and rain belts in the terrestrial system.

EFFECTS ON SETTLEMENT AND ECONOMIC LIFE IN THE COASTAL BELT OF PERU

It is only as we go north along the coastal belt of Peru that we find the belt of cloud and of slight precipitation on the seaward slopes of the Coast Range to have any influence upon settlement and economic life. Even there the fogs and rains support too thin and narrow a belt of grass to form the basis of an important pastoral industry. For that the rainfall would have to be more regular in occurrence and distributed over a broader belt of country. Coming irregularly the rains furnish abundant pasture in one year and fail altogether the next, so that the pastures dry up and the herds must be driven down into the valleys. When the rains come their effect is truly amazing and appears the more striking because of the extreme aridity of the country to eastward.

By good fortune I traveled through a part of the coastal belt of Peru during a period of rain and witnessed the delightful change of scene on passing from the burning desert into the belt of cloud. I repeat here the description of that experience already published in "The Andes of Southern Peru."²⁰

During the winter the desert traveler finds the air temperature rising to uncomfortable levels. Vegetation of any sort may be completely lacking. As he approaches the leeward slope of the Coast Range, a cloud mantle full of refreshing

²⁰ Isaiah Bowman: *The Andes of Southern Peru: Geographical Reconnaissance Along the Seventy-Third Meridian*, *Amer. Geogr. Soc. Special Publication No. 2*, New York, 1916.

promise may be seen just peeping over the crest (Fig. 19). Long, slender cloud filaments project eastward over the margin of the desert. They are traveling rapidly, but they never advance far over the hot wastes, for their eastern margins are constantly undergoing evaporation. At times the top of the cloud bank rises well above the crest of the Coast Range, and it seems to the man from the temperate zone as if a great thunderstorm were rising in the west. But for all their menace of wind and rain the clouds never get beyond the desert outposts. In the summer season the aspect changes, the heavy yellow sky of the desert displaces the murk of the coastal mountains and the bordering sea.

An early morning start in October enabled me to witness the whole series of changes between the clear night and the murky day and to pass in twelve hours from the dry desert belt through the wet belt and emerge again into the sunlit terraces at the western foot of the Coast Range. Two hours before daylight a fog descended from the hills, and the going seemed to be curiously heavy for the beasts. At daybreak my astonishment was great to find that it was due to the distinctly moist sand. We were still in the desert. There was not a sign of bush or a blade of grass. Still, the surface layer, from a half inch to an inch thick, was really wet. The fog that overhung the trail lifted just before sunrise and at the first touch of the sun melted away as swiftly as it had come. With it went the surface moisture, and an hour after sunrise the dust was once more rising in clouds around us.

We had no more than broken camp that morning when a merchant with a pack train passed us and shouted above the bells of the leading animals that we ought to hurry or we should get caught in the rain at the pass. My guide, who, like many of his kind, had never before been over the route he pretended to know, asked him in heaven's name what drink in distant Camaná whence he had come produced such astonishing effects as to make a man talk about rain in a parched desert. We all fell to laughing, and at our banter the stranger stopped his pack train and earnestly urged us to hurry, for, he said, the rains beyond the pass were exceptionally heavy this year. We

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rode on in a doubtful state of mind. I had heard about the rains, but I could not believe that they fell in real showers!

About noon the cloud bank darkened and overhung the border of the desert. Still the sky above us was clear. Then happened what I can yet scarcely believe. We rode into the head of a tiny valley that had cut right across the coast chain. A wisp of cloud, an outlier of the main bank, lay directly ahead of us. There were grass and bushes not a half-mile below the bare dry spot on which we stood. We were riding down toward them when of a sudden the wind freshened and the cloud wisp enveloped us, shutting out the view, and ten minutes later the moisture had gathered in little beads on the manes of our beasts and the trail became slippery. In a half-hour it was raining, and in an hour we were in the midst of a heavy down-pour. We stopped and pastured our famished beasts in luxuriant clover. While they gorged themselves a herd of cattle drifted along, and a startled band of burros that suddenly confronted our beasts scampered out of sight in the heavy mist. Later we passed a herdsman's hut, and long before we reached him he shouted to us to alter our course, for just ahead the old trail was wet and treacherous at this time of year. The warning came too late. Several of our beasts lost their footing and half rolled, half slid, down hill. One turned completely over, pack and all, and lay in the soft mud calmly taking advantage of the delay to pluck a few additional mouthfuls of grass. We were glad to reach firmer ground on the other side of the valley.

The heavy showers and luxuriant pastures of the wet years and the light local rains of the dry years endow the Coast Range with many peculiar geographic qualities. The heavy rains provide the desert people at the foot of the mountains such a wealth of pasture for their burdensome stock as many oasis dwellers possess only in their dreams. From near and far cattle are driven to the wet hill meadows. Some are even brought in from distant valleys by sea, yet only a very small part of the rich pastures can be used. It is safe to say that they could comfortably support ten times the number of cattle, mules, and burros that actually graze upon them. The grass would be cut for export if the weather were not so continually

wet and if there were not so great a mixture of weeds, flowers, and shrubs.

Then come the dry years. The surplus stock is sold, and what remains is always maintained at great expense. In 1907 I saw stock grazing in a small patch of dried vegetation back of Mollendo, although they had to be driven several miles to water. They looked as if they were surviving with the greatest difficulty, and their restless search for pasture was like the search of a desperate hunter of game. In June, 1911, the same tract was devoid of grass, and, except for the contour-like trails that completely covered the hills, no one would even guess that this had formerly been a cattle range. The same year, but five months later, a carpet of grass, bathed in heavy mist, covered the soil; a trickle of water had collected in pools on the valley floor; several happy families from the town had laid out a prosperous-looking garden; there were romping children who showed me where to pick up the trail to the port; on every hand was life and activity because the rains had returned, bringing plenty in their train. I asked a native how often he was prosperous. "*Según el temporal y la Providencia*" (according to the weather and to Providence), he replied, as he pointed significantly to the pretty green hills crowned with gray mist.

Transportation rates are still most intimately related to the rains. My guide had two prices—a high price if I proposed to enter a town at night and thus require him to buy expensive forage; a low price if I camped in the hills and reached the town in time for him to return to the hills with his animals. Inquiry showed that this was the regular custom. I also learned that in packing goods from one part of the coast to another forage must be carried in dry years or the beasts required to do without. In wet years by a very slight detour the packer has his beasts in good pasture that is free for all. The merchant who dispatches the goods may find his charges nearly doubled in extremely dry years. Goods are more expensive, and there is a decreased consumption. The effects of the rains are thus transmitted from one to another, until at last nearly all the members of a community are bearing a share of the burdens

imposed by drought. As always, there are a few who prosper in spite of the ill wind. If the pastures fail, live stock *must* be sold, and the dealers ship south to the nitrate ports or north to the large coast towns of Peru, where there is always a demand. Their business is most active when it is dry or rather at the beginning of the dry period. Also, if transport by land routes becomes too expensive, the small traders turn to the sea routes, and the carriers have an increased business. But so far as I have been able to learn dry years favor only a few scattered individuals.

A PRIMITIVE FISHER FOLK OF CHILE

Among native inhabitants the Changos are the only ones that seem to have had a regular dependence upon the resources of the coast in the belt of mist on the coast of Chile. They are a wretched tribe of Indians, primitive fisher folk of the desert coast, that early attracted the notice of Spanish writers. Lozano Machuca stated in 1581 that there were 400 Uros or Changos Indians, fishers and heathen, in the Bay of Atacama (Cobija). They are particularly interesting because fishing folk are extremely rare among Andean populations.²¹ They depended largely upon the sea for a living and in their dependence upon it resembled the primitive fisher tribes of Tierra del Fuego. Like the latter, they were necessarily nomadic, with canoes of sealskin and household goods limited to fishing gear, a few shells, and an indispensable water bottle formed usually of the stomach of the catfish. One of their chief settlements was Paposo, situated where the configuration of the coast appears to lead to an unusual amount of fog and likewise of vegetation. During the winter, when the sea is rough and the heavier cloud on the Coast Range produces more abundant vegetation, they were temporarily diverted from their maritime pursuits and hunted the guanaco that comes down from the cordillera. Since the Spanish conquest they have also acquired small flocks of goats and a few cattle that are pastured on the seaward slopes of the Coast Range.

²¹ Formerly the Uros of the Titicaca basin represented a pure type of fishing population. They still fish and hunt in the reed swamps about the border of Titicaca and those of the upper Desaguadero north and northwest of Ancoaquí.

CHAPTER IV

POPULATION GROUPS OF THE NITRATE DESERT

Deserts are no more alike than mountains or plains. In some there is a marked degree of rainfall, say ten or twelve inches a year, in others less than one inch a year; and of course there is a corresponding difference in the amount of vegetation. It was of an area near Tocopilla that the naturalist Ball wrote, "I found what I had often heard of, but in whose existence I had almost ceased to believe—a land absolutely without a trace of vegetable life."²²

While Philippi found the seaward slopes about Paposo at elevations of 500–1800 feet enriched with vegetation during nine months of the year, in the interior he passed two vegetationless stretches of 10 or 25 leagues respectively.²³ I have already spoken of the vegetationless character of the country eastward of Central Lagunas. Similarly riding to Quillagua southward of Central Lagunas in June, 1907, not a single spear of grass, not a single shrub or tree, not even a cactus did I see over a distance of 40 miles. The trail passed over sand and gravel, in and out of dry ravine beds, over thick salt deposits with rough buckled surfaces, and occasionally over a ledge of rock or a flow of lava. Nowhere was there any vegetation in sight. It was a thoroughly naked land. But these are exceptional conditions. As a rule at least a little vegetation is to be found along seepage lines in the ravines or desert hollows, where slow-moving ground water makes its exit. The plants of the desert are scattered in clumps and lines here and there in sympathy with the ground water or the surface drainage, and sometimes there are wide stretches of bush-covered country that depend upon natural subirrigation of the soil, as in the Coquimbo valley at the southern end of the Desert of Atacama, and in the Pampa del Tamarugal

²² John Ball: *Notes of a Naturalist in South America*, London, 1887, pp. 128–129.

²³ R. Philippi: *Observaciones jenerales sobre la flora del desierto de Atacama*, *Anales Univ. de Chile*, Vol. 14, 1857, Santiago, pp. 352–357; reference on p. 354.

east of Iquique. Yet where these stands of bush occur it is just as much a desert as the nitrate pampa, where there may be no vegetation at all.

DEFINITION OF THE DESERT

Those who have studied the Sahara and also the deserts of our Southwest have always remarked the relative abundance of vegetation in our deserts. A desert has become by definition not naked sand or rock but a place of small rainfall with a sparse and specialized plant and animal life. The point is worth making here, because upon a number of maps published before 1860 the term "The Great American Desert" was written over the western part of the Great Plains of the United States, over plains, valleys, and basins alike, where later exploration and settlement have shown a dependable water supply, a large acreage of irrigable land in the aggregate, and even local forests.²⁴ Because such settlement and exploration has steadily pushed back the borders of the American desert, it is sometimes supposed that the word "desert" can be discarded entirely and that we can look upon the whole of our vast public domain in the West as land that will some day be made habitable. Only those who mix patriotism and rainfall can envisage so rosy an outcome. As a matter of fact, we have an extensive area, as truly desert as the Sahara or Atacama—thin or meager vegetation, highly adapted in its resistance to drought through the narrowness and hardness of its leaf surfaces and its resinous protective epidermis, scattered settlements, extensive tracts without vegetation or human settlements, strong contrasts between day and night temperatures, excessively high midday temperatures, and a rainfall of but a few inches a year.²⁵

Except for those places where mountain streams flow out upon the piedmont border there is no vegetation to speak of in the Desert of Atacama between the basin floors at two

²⁴ Compare Floyd C. Shoemaker: *Traditions Concerning the Missouri Question*, *Missouri Hist. Rev.*, Jan., 1922, pp. 252-262.

²⁵ Compare "Routes to Desert Watering Places," etc., *U. S. Geol. Survey Water-Supply Papers 490-A, 490-B, 490-C, and 490-D*, Washington, D. C., 1920-22.

thousand to four thousand feet and the mountain flanks at eight thousand feet where the mountain pastures begin. It is substantially a barren region. While, as we have seen, there are tracts of scrub which depend upon natural subirrigation and occasional scattered patches of bushes and thorny plants along the ravines, the nakedness of the desert, its exceedingly thin plant cover, is the outstanding feature. And so barren is the desert pampa outside the borders of the oases that even a pastoral occupation is denied the inhabitants. If they raise flocks they must forage on the cultivated plants of the garden farms—alfalfa, millet, and the like—or be driven to the mountain pastures at elevations above eight and ten thousand feet. In some parts of the desert, as we shall see in the country between Copiapó and Vallenar, at the southern end of Atacama, occasional showers make possible a temporary range for flocks and herds, when grasses spring up and carpet the otherwise barren surface with green, but the dryness of the Desert of Tarapacá is so great that not even this temporary range comes into being. Beyond the oases there is nothing upon which man can depend, and access to the exceedingly thin mountain pastures is denied over much of the year by the extreme scarcity of springs and streams to which shepherds can drive their flocks to drink. Otherwise there is nothing except in some underdeveloped oasis where poorly watered marginal tracts, rarely more than a few square miles in extent, often salt-incrusted, support a wild growth of temporary grasses and perennial shrubs which for a short time bear a certain amount of succulent foliage.

DESERT OF TARAPACÁ

The Desert of Tarapacá contains rich nitrate deposits that have been worked for half a century and upon which is based the prosperity of the city of Iquique and several neighboring ports engaged in the nitrate business. Before the discovery of nitrate it was an almost uninhabited region. Towns, railways, and nitrate works have been made out-of-hand. They were built almost entirely by foreign capital and run by

foreign enterprise until recent years, when Chilean capital has been invested in the business in increasing amounts. The nitrate deposits are found along the line of a great depression, the continuation northward of the well-known "longitudinal valley" of Chile. The Coast Range rises abruptly several thousand feet above the sea, and between its moderate eastern slopes and the great western wall of the Andes is a depression with no outlet to the sea. The extreme smallness and infrequency of the rainfall have already been discussed. As we have said, more than a decade may pass without a single shower. Up in the mountains, however, the snow falls every winter, sometimes in local storms, sometimes over a vast area and reaching down to eleven and twelve thousand feet on the western mountain flanks. There are also rather frequent summer showers above eight and ten thousand feet. From these two sources the mountain streams derive their water supply and come down through steep-walled canyons to the great, broad-spreading alluvial plain at the western foot of the mountains. The streams have lost volume in their descent over the waste-strewn floors of the canyons and by evaporation, so that they reach the border of the piedmont as trickling brooks rather than powerful mountain torrents. Whatever of land waste they have carried along with them to the mountain border is here deposited, so that there is a steady building-up on the outer or western fringe of the piedmont from year to year.

When there are unusually heavy mountain snows and rains the streams reach the border of the desert in greater volume and spread their mantle of waste over many square miles of the desert, and in rare years of extraordinary rain and snow the streams may come down in such volume as to flow out over the nitrate pampa, as they did in 1906 when they flooded the pampa as far as the railroad line near the western border. Were these rare floods more frequent in occurrence, lakes would be formed and there would be outlets to the sea and the nitrate would be dissolved and washed away. It is the very great dryness of the climate and the infrequency of the floods that make it possible for the nitrate to remain.

SITUATION OF THE OASES

Places established where they could be reached only by exceptional floods would be without water for years at a time unless wells were dug to reach it or tunnels driven to ground water into the piedmont, such as we have described at Pica (p. 20). A settlement formed near the head of a mountain torrent, where the stream flows in full volume and so vigorously as continually to rework the materials of its valley floor, would likewise have a precarious existence as at Algarrobal (p. 68). Between these two extremes, however, it is possible to establish fields and irrigating canals and to enjoy a reasonably dependent supply of water. Precisely where a town will be located depends upon routes and trails to other towns and to the coast, so that there is some variation in the position of settlements along the western foot of the Andes. They are all alike, however, in that each depends upon a mountain stream that has a steadily diminishing volume westward, toward the desert. Each failing stream—Aroma, Huaschiña, Tarapacá, Mamiña, Quisma, Chacarilla, Huatacondo, Mani, and others—is the locus of a village or a line of villages. Each stream is deeply incised below the level of a broad piedmont slope. This is not merely a local condition. It extends along the western border of the Andes for five hundred miles, from Copiapó in the south to Pisagua in the north.

Of all desert places in South America, the villages and settlements along the Andean foot in Tarapacá and southward to the end of the desert have their fortunes most intimately determined by the local seasons. So far as their daily life is concerned, the coast might as well be a thousand as a hundred miles away. There are exceptions, to be sure, as where a mine or a source of water supply affects a remote mountain settlement, but on the whole it is a singularly self-contained series of communities. Before the development of nitrate only naked desert confronted them westwards. It discouraged occupation and movement in that direction. They looked to the mountains for their trade relations and for a part of their subsistence, not to the sea. It is of far more importance to

them that the winter snows, whose amount they mark with great concern, should be unfailing than that the vessels of distant ports and countries should ride at anchor off their repelling shores. Before the nitrate business was established the isolation of these towns was almost complete, and connection with the sea about as remote and unimportant as if they were in Central Asia or the heart of Australia.

Separated by wide stretches of barren rock and sand, these oases are almost like oceanic islands in the degree of isolation they possess. No historic movement of any consequence was ever originated in them. Their chief importance has been their service to land travelers, who have used them as links in the chain of communication from central Chile to southern Peru and from the mountainous hinterland to the coast. Without the water supply which they had made known and developed, the Inca Empire could scarcely have been extended to Copiapó and beyond. The oases furnished food, water, and guides to the Inca armies and were used as bases of operations in the progressive conquest of more southerly lands. Spanish conquest and occupation proved them similarly valuable.

LIMITATIONS OF TRADE AND DEVELOPMENT

When one conquers the waste spaces of the sea he has, within certain rather wide limits, his choice of lands to touch and products to secure; but here similar climate and similar conditions of soil and water supply are reflected in a lamentable uniformity of agricultural products. This means that there is no important trade from settlement to settlement, such as would develop if there were a specialization of products. Moreover, no one desert settlement has an exceptionally large water supply and by reason of this an advantage that would tend to make it a central point for the commerce of a wide region. Naturally also the surplus of one valley in a fortunate year cannot be sold to advantage if it consists of perishable fruit or bulky forage. The neighboring valleys are equally poor, and their capacity to absorb outside products is very small. It follows that the prices for staple commodities vary

greatly from place to place. In May, 1907, we found free pasture at the uninhabited grassy camp known as Caya, a tributary of the Chacarilla gorge; at the oasis of Chacarilla, a half-day's journey west, forage was free if the natural growth



FIG. 20—Algarrobo tree near Calama. It produces a pod with seeds; and these are valuable for fodder, especially in the dry years.

was desired; a few shillings a quintal, if it consisted of barley from a cultivated terrace; while at Pica, 30 miles northwest, it was 8 pesos, or \$2 gold, a quintal. Where there is none to spare, sometimes money cannot buy forage even of the worst kind; where there is plenty, it is very cheap; where there is a surplus, it is given away; and where there are no inhabitants,

it belongs to the first comer. It is the ratio of supply to demand at a given restricted and isolated locality that determines the price, not the ratio of the aggregate supply to the demand of the whole geographic province. In short, there are no

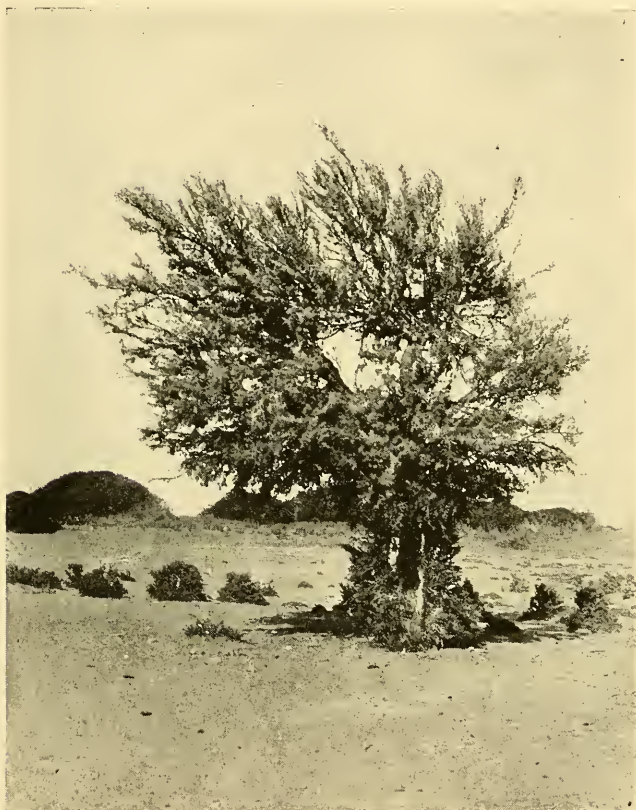


FIG. 21—Chañar tree at Calama. It is from this tree that a fruit is produced which is illustrated in Figure 22.

railroads and only the most primitive means of carriage for freight and passengers; and no specialized production or adequate equalization of surplus products of any kind. Furthermore, these primitive means of communication are expensive.

In general, one must either grow one's own produce or live very expensively. Only a rich mine or a thriving business enables one to live permanently upon the market and not

have one's own vine and fig tree. To the costly and hazardous transportation and the fact that each man lives for the production of his own food there is to be added the necessity of overcoming the inertia of the native. He has no ideals of the sort we know and live for. Wealth to him is the possession of comfort of a sort we should regard as miserable. Drink, gaudy attire, and long leisure to enjoy them, are in a way objects of veneration to the majority of the Indian inhabitants; and, in a large measure, it is true that only for them and the sterner necessities born of the meager years will be produced, even for pay, what another man is to consume.

It may, therefore, be said in general that the commerce of these towns is decidedly feeble, is carried on under great difficulties, and tends toward no natural self-initiated improvement. The interchange of products is only important under fortuitous or local conditions, as when clay deposits occur at one locality and not at another and so lead to the production of pottery; or where the culture of the grape is happily joined in one place to a good water supply, and the production of exceptionally good wine thus becomes a tradition. At present there is also a certain activity due to the opening up of mines in the mountains. The surplus products of the oasis of Chacarilla were formerly disposed of at the mines of Victoria, a few miles away, while some fruit and dried meats are taken from Pica and Matilla to the mines at Huatacondo in the deep gorge of Huatacondo and to Collahuasi in the high Andes, a week's journey away over a steep trail.

The precarious situation of most of the towns is one of their striking characteristics. The least accident may betray them. This is well illustrated by the history of a line of settlements in the Chacarilla valley. It was at one time a fertile and frequently visited district. But early in the seventies, as nearly as we could determine, a great flood came down the gorge, broke down the irrigating ditches, cut up the terraces, or deposited infertile sand, gravel, and even boulders upon them, overwhelmed orchards, and so generally devastated the farms and discouraged the inhabitants that all but a remnant of them moved away. The shock which such an occurrence

gives to a self-contained oasis is always terrific and sometimes fatal. I saw the irrigation works at the site of the now deserted village of Algarrobal. Here and there a neglected orchard tree or pepper bush, struggling along as best it can without irrigation, or the crumbling mud walls of some abandoned home are a mournful testimony to the ruin wrought by the flood in this once happy valley. The fragment of people now



FIG. 22—The chañar seed, or nut, in natural size. The outer covering is tough and hard but somewhat flexible. The white inner substance while dry and hard can be cut with a knife. Ground up, it is used as an ingredient for soup and to make so-called chañar bread (compare Fig. 21).

living within sight of the former more populous valley occupies a safer position. The tiny oasis of Chacarilla is perched high above reach of flood upon the slopes of a terraced alluvial fan, whose outer edge is protected by a stone wall. The small spring-fed stream discharging across the fan is led out upon the gardens and orchards by half a hundred diverting canals.

Apart from the vicissitudes due to such sweeping disasters the amount of land that can be put under cultivation varies much from year to year. In times of serious drought lands ordinarily habitable have to be entirely abandoned for the

time being. In the Quebrada de Mani, for example, the proprietors emigrate in dry years to return after a flood has restored the amazing fertility of the valley. According to the magnitude of the flood is the length of time for which their cultivation can be continued.²⁶ Attempts to increase cultivation have been made, but they have met with little success. Experiments conducted in the Pampa del Tamarugal have an interest scientific rather than economic. In the Pampa del Tamarugal there are places where the ground water is abundant and comparatively free from salts. In such spots wells have been sunk and small patches irrigated. Tirana is an example noted by Bollaert. Its unusual advantages gave it an early importance. It has served as a midway station between the oficinas and the oasis of Pica for Bolivian emigrants seeking employment in the salitreras. In 1850 another agricultural experiment was tried; the idea, it is said, being derived from the growth of corn from grain accidentally spilled by a muleteer in a hollow of the pampa. A depression is made in the ground so that the surface is brought within a foot or two of the ground-water level. This *chacra sin riego* is similar to the *hoyas* of the coast valleys of Peru described by Garcilasso de la Vega.²⁷

PERSISTENT CHARACTERISTICS OF THE OASIS TOWNS

The future of the piedmont and mountain valley towns is safely predictable. The small area of irrigable land, even with the maximum conservation of water supply, means definitely restricted groups of population widely separated from each other and as stagnant and self-dependent as isolated. Their limited development and the wide unproductive spaces to be overcome will always mean the absence of any improved means of communication, and no assistance can be expected in this direction. Railroads will never connect these towns except as they lie by chance upon the line of some future route

²⁶ Roch Latrille: Notice sur le territoire compris entre Pisagua et Antofagasta, *Bull. Soc. de Géogr. de Paris*, Ser. 7, Vol. 18, 1897, pp. 473-495; reference on p. 491.

²⁷ Garcilasso de la Vega: Royal Commentaries of the Yncas, Bk. 5, Ch. 3, *Hakluyt Soc. Publs.*, 1st Series, Vol. 45, London, 1871.

between mine and seaport. Pica is the largest town along the mountain front, and a branch line but 14 miles long would put it in touch with the port of Iquique via the Lagunas-Iquique nitrate railroad. Yet that short line has not been built and probably will never be built. Only exceptionally rich ores can make possible the costly transportation by carts and mule packs to the coast. The latter means are not found generally successful today with competing mines more favorably located with respect to railroads. The mines back of Taltal, for a long time exporting their ores by cart to the seaboard, had to be abandoned when the mountain railroad from Antofagasta to Oruro was completed. Before any railroads had been built, or at least only a few completed, competition between pack train and railroad could be sustained; but with the active extension of the railroads in South America only those mines that are on or near a railroad can survive. The remote, isolated, self-dependent, desert village is therefore a permanent feature. The traveler of a century hence will still find certain groups unaffected, in the main, by the industrial development of the mines and the nitrate deposits of the desert of Tarapacá. The bells in the churches of Caspana, San Pedro de Atacama, and Chiuchiu bear dates of the seventeenth and eighteenth centuries and have served a line of people whose life has come down from earlier centuries almost as unchanged as the peals of the bells that have ushered out the successive generations.²⁸

In spite of the disagreeable odors and filthy sights one sees about these desert towns, one's first and last impression of them is enduringly pleasant. From the desert trail, long, hot, and deep in dust, their inviting gardens are seen many leagues away, and at night a tower light on a commanding hilltop guides the traveler to their hospitable gates. Rows of refreshing orchard trees, neat squares of vegetable gardens, and a life-giving stream with clustering houses—that is the picture. In the twilight of morning and evening the strong

²⁸ Alejandro Bertrand: Memoria sobre la exploración á las Cordilleras del Desierto de Atacama, *Anuario Hidrogr. de la Marina de Chile*, Vol. 10, 1885, pp. 1-299; reference on pp. 288-289.

contrast of yellow plain and deep green foliage is most marked and lends to the view, in that otherwise cheerless land, an indescribable charm. There is a universal appeal in this aspect of home and a certain comfort and beauty amid the inhospitable surroundings of naked desert.

Each town has its patron saint, appropriate to the specialty for which the town is known or the condition amid which it exists. Thus at Pica, where excellent wine is produced, it is San Andrés, the patron saint of wine; at Canchones, a seat of *chacra sin riego*, it is San Isidro, the patron saint of farmers. Frequently the saint of one village is taken on a trip to a neighboring village. Thus, at the time of our visit to Pica, the Virgin of Candelaria was brought from Macaya, a copper-producing town of 600 inhabitants 60 miles northeast of Pica. She came asking for alms, for it had proved a hard year at Macaya, and an appeal was thus made to the generosity of the inhabitants of Pica. Their patron saint was carried out to meet the visiting saint, and with fife and drum the united procession returned to the village, parading the streets to the church of San Andrés.

Throughout many portions of this thinly populated, arid region of South America there is the most curiously interesting mixture of primitive and Christian worship. The old rites of the Indians are grafted upon a new creed, often with but a change in name and not in principle or symbol of worship. The rivers and the harvests are the forms in which they understand the Deity. The spirit of the old prayers for abundant rivers and rich harvests breathes through the new devotions, and the melancholy chants of the ancient Quechua or Aymará tribes or of the folk about the border of the Puna de Atacama often follow upon a fiesta in which the rites of the Christian religion are but new forms for an old and simple speech.

RELATION TO THE NITRATE SETTLEMENTS

The oases people are deeply rooted in the sites that they have chosen for settlement. Aloof from the sea, with no herbage afield, they have become sedentary to a high degree. Each

settlement is a self-centered unit; and formerly this quality was even more evident than now, when industrial development has stirred some of the desert settlements out of their age-old lethargy. Unchanging as the fundamentals of desert economy must be, in general, there are certain modifications due to industrial development. Thus the influence of the large city of Iquique, which must subsist entirely upon imported foodstuffs, is spread over a large radius. Pica and Matilla supply a part of the fruit and vegetables consumed at the port and through the exchange have acquired a taste for the products of the town. Laborers are in high demand through the nitrate region, and the population of the oases, crowded from the standpoint of water supply and food resources, are often drawn upon for the services of the nitrate establishment, though the most important supply comes from the more densely populated south.

Farther south an important group of oases of which San Pedro de Atacama is the center enters into wider geographical relations with the nitrate districts. It lies at a much higher elevation in a distinct border zone partaking of the life of both mountain and desert. It will be described later (Ch. XII) after the account of the trans-cordilleran cattle trade upon which it is primarily dependent.

THE DEVELOPMENT OF THE NITRATE DESERT

In extreme contrast to the old self-sufficient communities of the piedmont oases are the new groupings dependent on the exploitation of mineral wealth. The first coast settlement between Arica and Copiapó to attain any importance was the little Changos settlement of Cobija (latitude $22^{\circ} 30' S.$) established early in the eighteenth century as a customs house for suppression of active contraband trade in silver from the Bolivian mines.

Following the Wars of Liberation the first notable new development on the coast of Atacama was the resurrection of the port in 1829. The first step undertaken was careful organization of the water supply. The best well close to the



FIG. 23

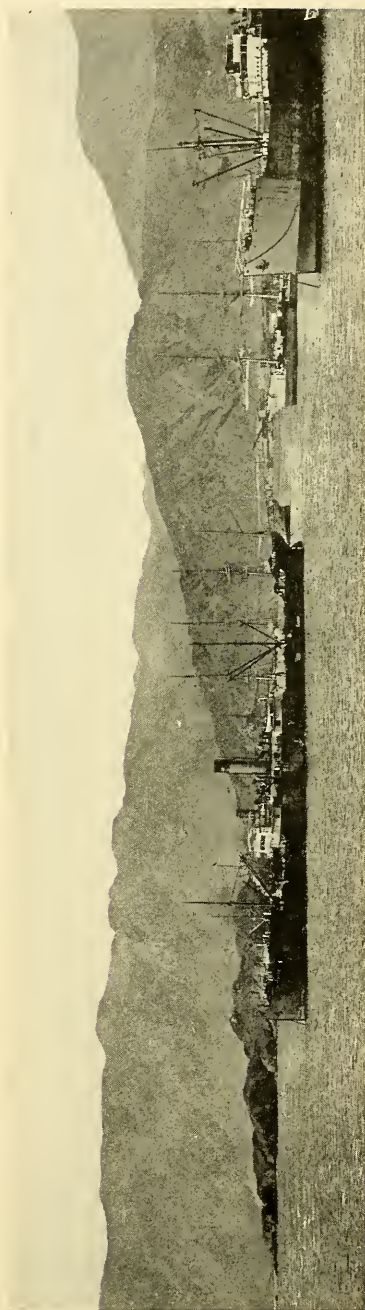


FIG. 24

FIG. 23—Panorama of the port of Taltal on the coast of Chile. Like most of the cities on the coast of Chile, Taltal stands on a marine terrace, here of unusual width, with protecting headlands and islands on either side.

FIG. 24—Ships in the harbor of Taltal, Chile. Thither comes regularly as to the other nitrate ports a great fleet of steamers and sailing vessels to serve the nitrate exporting companies and collateral trade.

shore was reserved for the government officials and garrison. The rest of the populace was supplied with water from springs in the hills back of the town, conducted in pipes and kept under lock and key, the daily quota being delivered to each family. More water might be purchased from a carrier who brought it from the interior. In those days the present of a barrel of sweet water from southern Chile or Peru was highly esteemed.²⁹ Small herds of sheep and goats were pastured on the mist-fed hill pastures, otherwise all produce came from outside: cattle from Argentina via Calama, foodstuffs by the sea highway. Gilliss describes the market as he saw it in 1851 when Cobija was credited with a population of 1500: "It was a matter of no little interest to witness the avidity of the population on landing the garden-stuff brought from Arica. Probably within ten minutes after the first boat-load of bags had been landed, all over town Indians, including soldiers, might have been seen stripping the rind from green sugar-cane . . . housekeepers bearing away piles of ears of maize, sweet potatoes . . . an hour later the beach—which had served as the impromptu market-place—was again bare."³⁰ Cobija served principally for the mines of southern Bolivia; but it was very incommodious as a port, and with the development of the desert and the establishment of Antofagasta in 1870 Cobija rapidly declined. According to the census of 1885 it had only 429 inhabitants, and that of 1907 gives no more than 35.

In the third decade of the nineteenth century began the great development of the provinces of Antofagasta and Tarapacá. Great aridity has here conserved vast resources of guano and nitrate of sodium (Chile saltpeter).³¹ Used locally as fertilizers from time immemorial their value to the European agriculturist became recognized less than a century ago.³²

²⁹ *Three Years in the Pacific, 1831-1834*, by an Officer of the United States Navy, 2 vols., London, 1835; reference in Vol. I, p. 302.

³⁰ *The U. S. Naval Astronomical Expedition to the Southern Hemisphere During the Years 1849-'50-'51-'52*. Washington, D. C., 1855; reference in Vol. I, p. 447.

³¹ For a summary of the problem of the nitrate and its origin see A. G. Ogilvie: *Geography of the Central Andes, Map of Hispanic America Publ. No. 1*, American Geographical Society, New York, 1922.

³² William Bollaert: *Antiquarian, Ethnological and Other Researches in New Granada, Equador, Peru and Chile*, London, 1860, p. 244.

In 1820 a cargo of nitrate was shipped to England, but the duty on it was high and it was thrown overboard. Other attempts also proved unsuccessful until 1831, when it found an English market and steady progress in exportation ensued. The first production centered round La Noria, where was built the first nitrate railway, a section of which was completed in 1870.

For a time, however, nitrate yielded first place to guano. This product first appeared in the list of important Peruvian exports in 1840. It rapidly brought the government an enviable source of revenue, and it was a main factor contributing to railroad construction in Peru.³³ From 1840 to 1867 the income from guano amounted to \$20,000,000, after which year decline set in with declining prices for the product. The chief source of guano was the Chincha and Lobos Islands, but some deposits were worked in Atacama, at Pabellon de Pica, for instance, where in 1874 new deposits were discovered along with those of other neighboring localities—Chipana and Huanillos. But at this time nitrate began to come to the fore.

The processes of extraction and refinement of the crude product, the *caliche*, and shipment from the salars, twenty to forty or more miles distant from the coast, involved problems of labor and human economy unknown in the simple exportation of guano from the coast cliffs and islands. For the maintenance of the people employed the locality, the immediate surroundings of the oficinas, produces nothing: water, food, houses—everything must be brought from a distance, and also means of transport for the distribution of such supplies.

PROVISIONING THE NITRATE SETTLEMENT

First comes the question of water. Very few springs and wells exist on the coast or pampa; and such as are found, especially on the pampa, are too saline for use. Water was first carried on mule back from the nearest source of supply. Then, as the nitrate industry expanded, distillation works were

³³ On the guano industry see R. C. Murphy: *The Sea Coast and Islands of Peru, Brooklyn Museum Quart.*, 1920-1922, and authorities cited therein.



FIG. 25



FIG. 26

FIG. 25—A part of the water system of Taltal. See Fig. 23, p. 74.

FIG. 26—Hauling water by mule cart from railway to mines near the southern end of the Desert of Atacama.

erected on the shore or pipe lines were laid to the sources in the cordilleran piedmont. Thus Iquique first got its water from the Pozo Almonte wells to the east and from Pisagua, 45 miles to the north. After the Peruvo-Chilean war the distillation plants were supplemented by water piped from Pica (compare p. 20), 56 miles away. Agitation for an improved supply led to a contract made in 1913 for the construction of reservoirs in the lower part of Quebrada Quisma.³⁴

The nearest local sources of food and fodder are the already described desert oases, but their resources are strictly limited in amount. In 1855 it was said that the oases did not produce enough alfalfa to support one-tenth of the mules engaged in transportation at the salitreras. Moreover, the new roads to the west have not entirely diverted the oasis trade from its old routes east. The mines of the cordilleran slopes take some of the oasis products; Matilla, for example, sends fruits to Huatacondo up the Chara valley.

For fodder and fresh provisions the nitrate zone looks chiefly to the valleys of through-flowing streams north of Arica and south of Copiapó. Formerly shipments from here were made only by water. The decks of the coast steamers (Fig. 28) resembled market gardens. The merchant proceeded on board at Valparaíso or Coquimbo with his stock of onions, squashes, cabbage, lettuce, asparagus, which he retailed at the desert ports as far north as Iquique or until his stock was exhausted. For the return trip he might lay in another stock at Arica to vend on the way south. The longitudinal railroad has, however, added a new means of transportation. The area tributary to the nitrate zone extends into central and southern Chile and into Argentina. On the rise of the industry the stream of cattle and mules coming over the cordillera to the mines of Atacama was in part deflected northward. For a time indeed the copper-producing district of Copiapó experienced a shortage. The northward movement progressed steadily, though today it appears to have reached the turning point in respect of the mule traffic; the network of the nitrate railways is now fairly complete, and the introduction of the

³⁴ Fernando López Loayza: *La Provincia de Tarapacá, 1912-1913*, Iquique, 1913.



FIG. 27



FIG. 28

FIG. 27—Sail car on the Antofagasta-Bolivia Railway near Calama, Chile. The regular afternoon wind is a dependable source of power for the return to town at the end of the day.

FIG. 28—Deck of the French freighter *Ville du Havre*, Lamport and Holt Line, showing vegetables in transit from the Huasco valley to the nitrate ports.

motor truck has already begun. Cattle and fodder also come from southern and central Chile. Before the end of the last century the influence of the nitrate zone had effected a change in the Chilean pastoral industry that is usually significant of the transition from meat production to dairying. The wheat lands of the Central Valley were plowed up and converted into cattle pastures and hay and barley fields to meet the increased demands of the north for meat and fodder.

IQUIQUE AND ANTOFAGASTA

The highway of the sea has called into existence the principal settlements of the nitrate zone, the ports. The older ports are those of Tarapacá where the salitreras were first exploited. Iquique, the nearest point of shipment for the first nitrate works, was in 1826 a fishing hamlet of about a hundred persons.³⁵ Thirty years later it was estimated to contain 5000 inhabitants and was the second port of Peru. Later, when Iquique came into the hands of Chile, it figured as the first port in the export trade of the country and has ranked as chief port and town of the nitrate district until lately, when Antofagasta has come to the fore. In 1899 Iquique's revenues from import and export trade amounted to over seven times as much as those of Antofagasta; in 1912 they were practically identical; and in 1915 revenues from nitrate alone were half as great again for Antofagasta as for Iquique. In sympathy with this development are the population changes effected in the two localities. Iquique had over 40,000 people in 1907; reduced to 37,421 in 1920. In 1907 Antofagasta had 32,496; increased to 51,531 in 1920.

The growth of Antofagasta has been extremely rapid. Just before 1870 nitrate exploitation was begun in the Salar del Carmen east of a point on the coast known as Playa Blanca.³⁶ Along the flat-bottomed quebrada leading to this point the nitrate was carried by oxcart, and thither also mules brought

³⁵ Bollaert, *op. cit.*, pp. 254-255.

³⁶ P. O. Sanchez: Fundación de Antofagasta, *Bol. Inspección de Geografía y Minas*, Santiago, 1913.

the silver ores from the Caracoles mines on the way to San Pedro de Atacama (see p. 172). To the port thus established was given the name La Chimba, soon afterwards changed to Antofagasta. Early growth was largely due to Chilean enterprise, so much so indeed that Bolivia recognized the right of the Chileans to exercise the privileges of the electorate and to hold office in municipal affairs. The future of the port was early determined by the construction of the railway laid from this point because of the easy gradient and low altitude (about 1800 feet) by which the Coast Range could here be crossed. By 1877 the line had reached Salinas, and it was projected to the plateau. But the nitrate war intervened, and construction to Oruro was not completed until 1892. Once this had been established Antofagasta entered a far broader sphere than Iquique. Iquique is a nitrate port pure and simple. Antofagasta ships tin and silver for the mines of southern Bolivia and borax for Ascotan as well as nitrate. Development of the nitrate zone south of the Loa is a comparatively late enterprise; sudden expansion began there in 1900.

The port of Antofagasta is now being supplemented by Mejillones. Antofagasta has a very poor natural harbor. Vessels must anchor in the open roadstead and discharge by lighter to the eight small moles. Congestion is not infrequent, and exposure to the heavy southwest gales may entail further annoying delay. Mejillones, on the other hand, has a splendid harbor protected by high hills from the westerly gales. Now that the railroad has been carried there, Mejillones is beginning to grow. In 1905 it numbered not more than a score of persons; now there are 6000.

Besides the problems connected with food and transportation the nitrate oficinas must also face the question of labor supply. Labor comes chiefly from the south and is notably migratory. The oficinas provide an outlet for the people of the irrigated valleys during times of drought. Dry years are now invariably followed by a wave of migration to the north.

Conditions in the nitrate market exercise a reciprocal effect on labor. No better illustration of this can be found than in

the crisis that arose at the beginning of the war.³⁷ According to the estimates of the Commission appointed to relieve the situation, there were in Tarapacá over 113,000 people practically all deriving their support directly from the nitrate industry. The nitrate oficinas accounted for 53,154, taking only the laborers and the women and children dependent on them. The pampa towns, some of which are absolutely dependent on the industry and were at once depopulated, contained about 20,000. The ports added 45,000 for Iquique and 5000 for Caleta Buena, Junín, and Pisagua. By the beginning of September, 1914, half the oficinas had been closed down, and their laborers thrown out of employment. Towards the end of October the Government had assisted 22,046 to depart by the port of Iquique and 676 from Pisagua. By 1917 conditions were restored to normal.

³⁷ *Commerce Repts.*, Sept. 25, Nov. 10, Dec. 9, 1914. The mid-century population of Tarapacá is given thus: on the coasts engaged in fishing and commerce, 3000; on the salitreras, 2000; in the oases, 4000 (Francisco Puelma: *Apuntes geológicos i geográficos sobre la provincia de Tarapacá en el Perú*, *Anales Univ. de Chile*, 1855, Santiago). For purposes of comparison it is interesting to add the population figures according to the last four censuses, 1885, 1895, 1907, 1920. For the province of Tarapacá they are respectively 45,086, 89,751, 110,036, 100,353; for the province of Antofagasta 33,636, 44,085, 113,323, 172,330.

CHAPTER V

POLITICAL GEOGRAPHY OF ATACAMA

The coastal desert of Chile and Peru was the field of action of one of the two greatest wars in the last hundred years of South American history. Its land battles involved a type of desert marching remindful of the campaigns of Alexander in Asia, and the fighting was notoriously desperate; its sea battles engaged, among others, steel-clad vessels of the kind first used in our Civil War; Lima, the capital of Peru, was occupied by Chilean troops for three years (1881-1883); one of the articles of the treaty involved the question of a plebiscite whose delayed settlement was the chief objective of the Tacna-Arica Conference held at Washington in 1922 and now submitted to the arbitration of the President of the United States. By the terms of the Treaty of Ancon, which closed the war, Peru lost control of all of her rich possessions in the desert south of the Rio Sama (latitude 18° S.). Among the fourteen articles of the treaty, six relate specifically to the guano deposits of the region, one to the nitrate deposits of Tarapacá, while an eighth refers to the territory in which these deposits occur. Tarapacá was ceded outright to Chile. The Lobos Islands, off the coast of Peru, were to be administered by Chile until one million tons of guano were extracted, when they were to be returned to Peru. Bolivia lost all of her maritime territory and became a landlocked state.

The causes of the War of the Pacific may be understood better by appreciating the fact that Peru based her territorial claim upon early treaties and royal decrees, while the claim of Chile was based upon effective occupation and development and allegations of lack of good faith on the part of Peru and Bolivia. The two claims are separated by a long period and are incommensurable; their settlement would not have been a difficult matter for a calm tribunal; but with a great stake—the rich nitrate fields—in the hazard, war was

the inevitable consequence. The claims will be briefly examined, for they, as well as the war, have geographic relationships of deep significance.

THE PERUVO-CHILEAN BOUNDARY IN HISTORY

All of the vast territory of the Spanish crown in South America was long divided into separate viceroalties, and out of these in a sense the future republics were made. The lines of demarcation between the political units of colonial times were laid down in conformity with the approximations of the early Spanish adventurers, or *conquistadores*, who overran the country; and these lines, recognized by royal decrees and in practice, were the basis of the treaty articles, relating to boundaries, that were framed after the wars of liberation. The present territory of Chile was disposed of in three concessions. Pizarro, the conqueror of Peru, in 1529 obtained a concession of 470 leagues, extending from latitude $1^{\circ} 20'$ to $25^{\circ} 31' 24''$ S. A second concession was granted to Almagro, Pizarro's lieutenant, the third appointee being Almagro's successor, Valdivia.

The citation of different authors to show acknowledged ownership by Peru or Chile or Bolivia has been a favorite method of argument by partisan writers of each one of these countries. The method is invalid on the common ground of thorough inconsistency; for each may easily bring, and each has brought, to notice as many important "authorities" as the other. Several typical illustrations are in point. In 1789 the Spanish sovereign dispatched a scientific expedition for the purpose of exploring the west coast of South America. The commanders, Malaspina and Bustamante, had access to all the documents in the archives of Spain relating to the Indies. Upon completing their observations the explorers drew up a map of the world on which the twenty-second parallel was represented as the northern limit of Chile, thus assigning to Chile a larger share of the disputed territory than she actually possessed or than she had even claimed since the first foundation of the colony. Absurd as this assignment appears as proof of ownership, it is, nevertheless, gravely adduced in a

serious argument by Alejandro Fierro, Minister for Foreign Affairs in Chile.³⁸ Another disinterested and early writer, the Jesuit historian Juan Ignatius Molina, in an important general work on Chile,³⁹ presented a map of that country as the frontispiece of his book and indicated the northern boundary north of the Rio Salado, approximately on the twenty-fourth parallel. (Molina shows the Rio Salado at 25° S., actually it is 26° 20' S.) The number of such contradictions is hardly exceeded by the number of writers themselves. The worthlessness and unknown character of the region made it a matter of trifling consequence to which country the maps assigned it.⁴⁰

The controversy is not to be settled by reference to royal decrees, which seem to conflict in proportion to distance from the territory which they attempt to assign. After the conquest of southern Chile, Almagro received from the Spanish crown a grant of 200 leagues south of the southern limit of Peru⁴¹ and became governor of this territory, with specific instructions as to the manner of organization and administration of the natives. Santiago, the present capital of Chile, was founded by Pedro de Valdivia, who was appointed successor to Almagro by La Gasca, then governor of Peru, in the name of the Spanish crown. La Gasca wrote the Council of the Indies on May 7, 1548, of the appointment of Valdivia and incidentally notes the limits of the territory within his jurisdiction: "—from Copiapó, which is at twenty-seven degrees from the equinoctial line toward the south until forty-one degrees to the north, to south straight meridian, and wide from the sea inland 100 leagues west to east," a concession which was confirmed by the Spanish emperor, Charles V. But the Royal Decrees of June 3, 1801, and June 26, 1803, declare that Paposo (about 25° S.) was then considered as the capital of the entire coast and des-

³⁸ *Diario Oficial de la República de Chile*, in translation from official documents published as "Narrative of the Events Which Led to the Declaration of War by Chili Against Bolivia and Peru," London, 1879, pp. 10-11.

³⁹ G. I. Molina: *Saggio sulla storia naturale del Chili*, Bologna, 1782.

⁴⁰ See in this connection the northern boundary of Chile, on the map of 1839 reproduced as Fig. 50 on page 177.

⁴¹ J. T. Medina: *Collección de documentos inéditos para la historia de Chile desde el viaje de Magallanes hasta la batalla de Maipo 1518-1818*, 30 vols., Santiago, 1888-1902; reference in Vol. 4, "Almagro y sus compañeros," pp. 239-243, "Decree of July 19, 1534."

ert of Atacama and subject to Santiago de Chile, thus invalidating the earlier allotment to Almagro. These decrees were subsequently altered, however, by the Royal Warrant of October 10, 1803, which ordered that the desert of Atacama should be separated from Chile and assigned to Peru.⁴² The warrant was never carried into effect, and later administrative acts only increased the confusion which the contradictory and unenforced decrees and warrants served if they did not create. For example, at the close of the eighteenth century the bay of Paposo was the center of commerce on the coast of Atacama and the center of almost the whole population of the region. It was governed by a judge appointed by Chilean authorities. Likewise, in 1679, more than a century earlier, the discovery of tillable lands at Paposo (then the Bay of Nuestra Señora) led to the issuance of a grant to the discoverers by the governor and captain general of Chile.

It is clear indication of the confused state of affairs that in spite of these acts plainly pointing, in themselves, to at least a reasonable claim of ownership by Chile, the desert of Atacama, north of the twenty-seventh parallel, was never claimed by Chile in the various constitutions promulgated between the years 1822 and 1833, in each of which the phrase, the "desert of Atacama," indicates the northern boundary of the republic. At that time the phraseology of the boundary articles was of little concern; the desert was of so little worth that it was thought an ideal boundary. Territorial rights were understood and exercised by Peru within the limits of the twenty-seventh parallel without question on the part of Chile, a point upon which there is abundant evidence, both in the treaties between these two countries and in the individual acts of the merchants and developers of the resources of the region.

PACIFIC LITTORAL ACQUIRED BY BOLIVIA

Such was the status of the question down to the time that Bolivia acquired a portion of the Pacific littoral lying between

⁴² *Diario Oficial de la República de Chile*, in translation from official documents published as "Narrative of the Events Which Led to the Declaration of War by Chili Against Bolivia and Peru," London, 1879, pp. 9-10.

the twenty-third and twenty-fourth parallels. The right of Bolivia to this territory was recognized by Chile in a number of acts, of which the following may be instanced. Between the years 1842 and 1845 the Bolivian Consul at London brought suit against the Chilean frigate *Lacaw* for having clandestinely taken a cargo of guano from the seaboard recognized as belonging to Bolivia. The British law courts pronounced sentence upon the ship; and no objection was offered by Chile either to the suit or to the sentence.

The treaty between Bolivia and Peru provided for a boundary between those countries, and Chile was therefore separated from Peru by a broad strip of desert territory owned by Bolivia. Under these circumstances and with the historical facts of the case in mind, but one conclusion can follow. The northern boundary of Chile was long at the twenty-seventh parallel, but the vigorous claims of Chile to all the territory as far north as the twenty-fourth parallel resulted in this as the final boundary between Bolivia and Chile, as determined by the treaty of 1874. It would seem from an examination of these facts that the question of boundaries would be settled along lines guided by the treaties of 1874 and the years immediately succeeding, which made specific mention of towns, ports, parallels, and the like.

SIGNIFICANCE OF NITRATE AS A NATIONAL RESOURCE

The intense rivalry of the neighboring states with respect to the ownership of the nitrate fields has its foundation in the exceptional value of the deposits: they proved to be richer than the guano deposits, at first considered the chief resource of the desert coast.⁴³ The nitrate beds lie near the sea, are worked with comparative ease, and are in great demand among the densely populated countries of Europe as fertilizer to maintain the high productivity of their long-tilled lands. Further-

⁴³ In regard to the importance of the Chilean deposits it is of interest to note that in 1920 Chilean nitrate accounted for about one-third only of the world's production of fixed inorganic nitrogen; two-fifths came from atmospheric nitrogen, a source insignificant before the World War. The cost of producing the latter tends to come down while the former goes up (E. Kilburn Scott: *Nitrates and Ammonia from Atmospheric Nitrogen*. *Journ. Royal Soc. of Arts*, Vol. 71, 1923, pp. 859-876).

more, the deposits are unique in their occurrence. Chile exchanged her national debt for a national endowment when she took possession of Tarapacá, and Peru lost a source of wealth that left her financially troubled. Chile sought to cripple her rival completely that there might never again arise any question of ownership over so important a source of wealth, and the most effective means at hand was the complete annexation of the nitrate fields. The year before the war, 1878, Tarapacá yielded 300,000 tons of nitrate. In that year the foreign debt of Chile reached \$35,000,000, and the yearly expenditure had risen to \$15,000,000—a condition met by heavy taxes burdensome to the people. Quite as much for its political effect as for the territorial questions involved, the government sought relief in the acquisition of the rich nitrate deposits of the desert.

Before the war with Peru and Bolivia copper, wheat, and wool were among the principal exports in total value. By 1891, ten years after full production following the war, nitrate and iodine (a by-product) together had a value five times as great as the wheat exported and seven times that of copper; and by 1902 their combined value was fifty times that of wheat and eight times that of copper. The significance of the nitrate export tax in Chilean finance today is illustrated by the fact that during the period 1895–1910 the export duties on nitrate and its principal by-product iodine constituted between 44 and 56 per cent of the total revenue received by the government.⁴⁴

It must also be remembered that the moment Peru's forces were overthrown, that moment the large income derived from the high export duty on nitrate was diverted to the Chilean treasury. No long period of recuperation was necessary as in the case of an agricultural region overrun and devastated by invading armies. Neither in this war nor in the revolution of 1891 in Chile was there any really serious interference with the nitrate establishments that are the life of the region. All parties to the conflict were wise enough to see the plain folly of disturbing the goose that laid the golden egg. Nitrate exports continued much as usual, and export taxes were collected

⁴⁴ C. A. McQueen: *Principal Features of Chilean Finances, Suppl. to Commerce Reps.*, Nov. 26, 1923.

as usual; and at once money began to flow into the depleted Chilean treasury.

STRATEGY OF THE WAR

It was a favorite saying of old Marshal Castilla that when Chile bought a battleship Peru should buy two, and the statement was completely vindicated by the events of the war with Chile. No longitudinal railways existed then which could in even small measure take the place of the ocean highway. The railways ran at right angles to the coast and were all short. Those in Tarapacá did not even run near towns capable of supplying food and water; they were built for nitrate exportation, and it was more important to reach these fields directly than it was to touch at the insignificant sources of food supply in the desert.

The first contact with the raw and naked desert occurred after the seizure of Antofagasta (Feb. 14, 1879), when Colonel Sotomayor led an expedition of about 500 men against the oasis of Calama in the Loa valley at the southern end of the desert of Tarapacá and against the mining district of Caracoles about forty miles to the south. The detachment was obliged to transport water sufficient to last many days, to endure great heat by day and cold by night, to cross steep mountain spurs with an excessive amount of camp impedimenta, and to be in fighting trim when its objectives were reached.⁴⁵

CONTROL OF THE SEA

On April 5, the Chilean fleet sailed north to blockade Iquique and harass the coast from its base of operations at Antofagasta, where an army was stationed to follow up the successes of the navy. The Chilean admiral was instructed to destroy all facilities on the Peruvian coast for the shipment of guano and nitrate, thus suspending the chief source of Peruvian income. Pisagua was shelled, piers and wharves demolished, and lighters wrecked. Iquique was blockaded and became the

⁴⁵ Diego Barros Arana: *Histoire de la guerre du Pacifique, 1879-1881*, 2 vols., Paris, 1881-82; reference in Vol. 2, p. 52.

rendezvous of the Chilean fleet in harassing the Peruvian coast. The 1400 miles of Peruvian coast line is broken by only thirty valleys where supplies of food may be obtained in crossing the barren desert.⁴⁶ Rapid movement of troops from place to place is, therefore, impossible by land; and, when the Peruvian navy was destroyed, each military unit was obliged to work out its own problems alone. Chile, on the other hand, was able to concentrate her entire force upon a single point and crush her opponents, then move on to the next point, certain that her transports were free from danger. In this way it was not long until Chile had control of the entire littoral.

The blockade of the coast ports of Tarapacá is a far different thing from the blockade of the ports of a self-contained country. There are no streams on which ships of war can be built and sent to sea to run a blockade, no railways for the roundabout transmission of goods, not even the bare necessities of life. Light mountain artillery can be taken over the desert with difficulty, heavy siege guns are impossible of transportation. One of the most interesting maneuvers of the war was carried out at Tacna and Arica and illustrates admirably the isolation of the various units of the widely-scattered Peruvian army. After the preliminary events in Tarapacá and the retreat of the Peruvian forces to Arica, Chile began the campaign against Arica, then the most important port in southern Peru. The plan included the separation of Arica and Tacna, which are connected by rail, and the shutting off of supplies coming to the Peruvian army from Tacna and Moquega. Ten thousand men were embarked at Iquique and Pisagua, and, on February 26, 1880, they landed at Ilo and Pacocha, at the mouth of the Moquega valley (Fig. 1). Using the railway, the Chilean forces were transported up valley, and in the battle of Torata, 15 miles northeast of Moquega, the Peruvians were defeated, and Tacna was isolated from the sea. The route from Moquega to Tacna followed by the Chilean forces is interrupted by the valleys of the Locumba and Sama, the only two places where water may be secured for man or beast. The in-

⁴⁶ G. I. Adams: An Outline Review of the Geology of Peru, *Ann. Rept. Smithsonian Instn. for 1908*, pp. 385-430; see maps opp. p. 430.

tervening plains are sandy, with steep descents toward the valleys; and horses and men were so parched with thirst that water had to be carried to the amount of 40,000 liters for each day spent in the desert.

DIFFICULTIES OF A DESERT CAMPAIGN

In spite of the desperate natural difficulties the Chileans were nearly always successful, for their armies were almost uniformly larger than the armies of the allies, their guns were larger and more modern, and they fought with a fierceness and courage that cannot be overestimated. But the desert was no less difficult for the Peruvians than for the Chileans. Great efforts were made to send relief to the army at Tacna, but desert country intervened, and before relief came the Chileans had reached the place and invested it. Supplies of war were shipped with difficulty by both parties, and the superior mounts of the Chilean cavalry were in themselves a powerful factor in overcoming the desert sands.

It must also be recognized that defeat in the desert is a far different thing from defeat in a fertile country. Time and again when the allied forces (Peruvian and Bolivian) were overwhelmed, the men scattered to the four winds for safety. The desert fought them as fiercely as did the Chileans. In the battle of San Francisco, which secured Iquique to Chile, the success of the Chileans was not defeat to the allies but ruin. The allied army was without food, without stores of any kind, and without a base of supplies. The Bolivians retreated by way of the desert and mountain valleys to the interior; the surviving Peruvians began their retreat at midnight, dragging their guns laboriously over the trackless desert for a distance only to abandon them finally. The Chilean army was 10,000 strong. Against the antiquated guns of the Peruvians they opposed thirty-two long-range field guns and a large force of splendid cavalry. They were also connected with a railroad base, and supplies of water and food were regularly delivered. After three days of terrible heat, hunger, and fatigue, the men were finally brought to the ravine of Tarapacá, practically

famished. The final march had occupied fifty hours, but only a short rest could be enjoyed, for the oasis is tiny. During a part of the retreat the army marched along the edge of the cordillera. At one time they rested in the gorge of Aroma, the next day at the oasis of Camiña with its green clover fields and vineyards, and then followed a long desert march to Camarones and Arica (Fig. 1).



FIG. 29—El Morro, the hill of Arica, scene of a famous battle of the War of the Pacific (1879-1883). The town is north (left) of the hill and is the seaport for Tacna, an interior oasis, besides being one of the three Bolivian railway outlets on the Pacific. (Photograph by Professor Bailey Willis, Chilean Earthquake Expedition, Carnegie Institution of Washington.)

A short half hour's walk southwest of the seaport town Arica, and one has crossed a low ridge beyond which stretch miles of yellow sand and barren desert plateau. There, in a lonely spot, harried by the wind and blasted by the shifting sands, is a group of low wooden crosses. They lean at every angle, some are overthrown, all bear rude inscriptions. Projecting from the sand are portions of rough shoes and rags from old uniforms, and scattered about are rusty cartridge shells of antiquated design. These are the rude memorials of the Waterloo of the War of the Pacific.

The slope at whose foot these marks are found leads up to El Morro, the 670-foot hill of Arica, which overlooks the sea. Here was fought one of the hardest battles of the war; and here, too, are the works of defense, although the Chileans have

dismantled the old fortifications and all but obliterated the old defenses. A few pieces of steel rails, bent and twisted; scraps of cannon and an occasional cartridge; the spokes of gun carriages, still driven into the solid rock; a few rifle pits; these are all that remain to tell of an heroic defense and a fierce irresistible attack that drove the Peruvian forces from what had been considered an impregnable position. Steep slopes, in some places sheer, defend the hill on all but one side, and it is little wonder that Peru trusted it greatly. Its loss ended the most serious opposition that Peruvian forces offered the Chilean invaders.

With the fall of Arica, Chile controlled the coast line from the Strait of Magellan to Mollendo in southern Peru. The navy moved north and occupied the San Lorenzo Islands opposite Callao, the chief port of Peru. The islands had not been fortified by Peru, although they control the entrance to the harbor; and, using them as a base, it was not long before the Chilean fleet had bombarded the town and put the Peruvians on the defensive about their capital city. In the effort to deprive Peru of all means for continuing the war, a naval marauding expedition was fitted out; and, certain that each town could derive no assistance from a neighboring valley, it proceeded to lay waste the coast from Callao to Paita.

CONTINUED IMPORTANCE OF SEA CONTROL

The tactics of the fight at Lima again illustrate admirably the dependence of success upon control of the sea. Chile, safe at the San Lorenzo Islands, gathered supplies and completed her preparations without interference from the enemy. The Peruvian defense, stretched out for eight miles along a line of hills near Lima, was apparently very strong, and it was suggested that the long line be outflanked on the northeast; but the plan would have required breaking communications with the fleet and making a long march of fifteen miles through the desert with the men tired out at the beginning of a hard fight. The advance was therefore made with the left wing on the seashore. After hard fighting and repeated cavalry and bayo-

net charges, the Peruvian army was completely routed, and the first line of defense was abandoned. The second line of defense was carried two days later, January 15; and after stubborn fighting Lima itself was occupied on the 16th. The president and many of the Peruvian officers fled to the high mountain valleys. Here also fled remnants of the Peruvian army that kept up a guerrilla warfare against isolated Chilean detachments until finally Chile was obliged to send small expeditions into the interior. Bolivia could do little in support of her ally. Some supplies were shipped overland from Buenos Aires to La Paz and Lake Titicaca for the defense of Arequipa, but this town also fell into the hands of the Chileans and furnished a base from which to overrun the country and suppress the last scattered activities of the bands of guerrillas.

THE CHILEAN REVOLUTION

It is interesting to know that in the Chilean revolution of 1891 the general principle of control of the sea was illustrated again as neatly as in the war with Peru twelve years before. Almost without warning, the rebel fleet sailed away from the harbor of Valparaiso and in a few days dropped anchor in the nitrate ports, which they seized without any real resistance. There they enjoyed a measure of security which seems almost ridiculous until one understands the physical geography of the region. A campaign by land was out of the question, even had President Balmaceda enjoyed the support of his people. There were no railways; the villages along the line of march were small, wretched things which can give but little assistance to a passing caravan to say nothing of a hungry army. The one route possible was the sea route, and there were no transports, even had a part of the fleet remained loyal.

Secure in their desert ports, the rebel leaders collected export taxes on nitrate and with the proceeds bought supplies of war—modern guns, ammunition, clothing, and the like—and recruited the army until it was ten thousand strong. The government was crippled to just the degree that the rebels had profited. The funds that formerly were relied on were suddenly

withdrawn, and it was a financially weakened opposition that faced the rebel leaders when they finally sailed down to take Valparaiso. A landing was made, whole companies of the government troops went over to the rebel camp, and after several days fighting the lines were closely drawn about the city and it fell. Parallels to the experiences of the earlier war were both numerous and close. Today the conditions are somewhat changed, for although the sea is still a main highway of commerce and war, the great longitudinal railway line now completed to Pisagua⁴⁷ offers an alternative route.

It will always be true, however, that concentrated naval strength can offset the effect of land operations throughout the coastal belt of Atacama. There is no permanent military value in the possession of interior points alone. Only through the free use of the coastal outlets can the nitrate business be sustained. The control of the sea continues to be the prime consideration in the military geography of the desert coast.

⁴⁷ The state-owned longitudinal line runs to Pueblo Hundido (20° 40'); the Antofagasta-Bolivia railroad (British-owned) has taken over the Chilean Northern railroad extending to Pintados (20° 50') (J. M. Macleod: *Report on the Financial and Industrial Conditions in Chile*, Dept. of Overseas Trade, London, 1923).

CHAPTER VI

THE SOUTHERN MARGIN OF THE DESERT

After a journey over the Puna de Atacama in 1913 I crossed the Desert of Atacama by way of the oasis of San Pedro de Atacama and a few weeks later started for the southern end of the desert to study the physical setting of the towns and settlements there and also their social and economic structure. The day before I sailed for Caldera, the port of Copiapó, the sea became rough, and we were told it would be necessary to take the train to Coloso, a port two miles south of Antofagasta. There is at Coloso practically nothing more than a beach fronting a very narrow terrace formed in a hollow of the coastal hills where a point of land projects northwestward and cuts off the waves that sweep in from the open sea. This port faces the north while Antofagasta faces south, and when the latter is out of commission because of a heavy sea, the former is used instead. All the port facilities are for the nitrate service, and there are no small boats for passengers. The distance being but two miles, rowboats are sometimes allowed by the port captain at Antofagasta to go by sea to Coloso so that passengers may embark there, though the charges are thereby trebled.

CALDERA: THE PORT OF COPIAPÓ

One of the most prominent things to be seen on landing at Caldera is the water-evaporating plant. This and the smelter just outside the town, the railway station, and the custom-house form the chief constructions of this interesting port. The town was once much larger, when the copper mines of Copiapó were among the most important in the world, but now it is a very unimportant place despite its fine natural harbor—one of the best on the coast. It would again become of considerable importance if the projected railway to Argentina could be built, since a good deal of the produce for the nitrate

fields would pass through Caldera on its way north from Argentina. Opposition to such a railway from Salta to San Pedro de Atacama, farther north, or from Tinogasta to Copiapó, is of various sorts.⁴⁸ It is argued by some Chileans that in case such a railway were built Argentina might obtain control of the nitrate fields, and Chile has not forgotten the lesson of the revolution of 1891, when the revolutionary party, by taking the nitrate fields, captured the principal revenues and equipped an army and a fleet at its leisure.

The ports on the desert coast of Atacama have altogether primitive equipments. About 1910 the imports at Caldera rose very rapidly, and one might suppose from the statistics that this meant a rapid increase in the business of the hinterland. The real reason was that the port of Antofagasta was crowded on account of the rapid growth of the nitrate business at that time and the necessity for importing huge quantities of bulky railroad material. Merchants found that it took from thirty to forty days to free goods from the customs officials. To avoid the difficulty the Antofagasta merchants unloaded their goods at Caldera, paid the government duties, reloaded them, and discharged them at Antofagasta.

The original port for the valley of Copiapó was located at Puerto Viejo, in the Bay of Copiapó, and near the mouth of the Copiapó River; but there was no protection from heavy seas, and when mining interests were sufficiently developed a new port was sought and the old one completely abandoned. In disposing of the land at the new port the inhabitants were given situations as closely corresponding to those they had enjoyed in the old port as could be managed. With the development of Caldera and better transportation facilities connecting with the railway inland, several other "ports," little copper-exporting stations, for example Flamenco, north of Caldera, and Obispio, between Flamenco and Caldera, were abandoned and for a time were without any inhabitants at all.

⁴⁸ It is said that agricultural interests in Chile are opposed to the line in anticipation of competition of Argentine farmers. Unless the Chileans consent to the Salta scheme the Argentine government will not consent to the proposed southern transandine route through Lonquimay (38° 30'). For details of the proposed Salta-Antofagasta line see *The West Coast Leader*, Oct. 9, 1923.



FIG. 30—Copiapó from the eastern bank of the Copiapó River, looking north. The river is at low-water stage, and the effect of low water is heightened by the withdrawal of water for the city gardens and the up-valley farms.

All such ports are bound to have a more transient population than the valleys which they serve, for both the mines and the farms of such a valley have a variable output even when their population changes but little, and the port is dependent altogether upon the trade of the hinterland. Caldera once had 5000 inhabitants, but many of them have moved away, and the population of the town is now only 2500.

COPIAPÓ: HISTORY OF THE CITY

At first sight a desert town of ten or twelve thousand inhabitants appears to be a place of great importance. Such a town is Copiapó. A few houses two stories in height, a church or two with massive bell towers, well-kept parks, ample government houses, and long streets give a strangely cosmopolitan air in contrast to the usual desert town with one or two thousand inhabitants, for the "spread" of a one-story city is amazingly large. Were the population of New York City to be spread out in this way, it would cover about 2500 square miles of territory, or half that of the state of Connecticut; and were its food and forage supply organized on the same local basis it would require an area probably as great as that of New Jersey, 8000 square miles, and possibly as great as Maryland, 12,000 square miles. A business organization such as New York exhibits today would be unknown in an extended city like Copiapó. Instead of a compact section like lower Manhattan there would be many nuclei of business. Consider the mileage of wire needed to supply a telephone system for such an extended town, the mileage of street-car tracks, the distances to cover, and the heavy cost of all these. A one-story town cannot assume such a burden. Copiapó takes its time. If you wish to see a man living across the river or consult a ranchman two miles up valley you do not telephone but walk or ride a horse or mule instead, and your business is done not in two minutes but in two hours or in a half day. If your affairs move slowly so do those of everyone else.

Copiapó is one of the most attractive cities in the desert country of South America. In historical interest it surpasses

all other towns on the west coast save only Lima itself, the capital of the old Viceroyalty of Peru. From the time of the later Inca rulers who extended their empire into this remote desert valley and through the period of the great colonial governors it was a post of critical strategic value. In the period of modern industrial development it has at times held first place among the cities of Chile for its production of minerals. Its geographical situation has imparted to its settlement and history and to its social and economic structure alike, certain highly distinctive qualities.

I visited Copiapó in July, at the time of the so-called "winter" of the southern hemisphere, but the freshly irrigated alfalfa meadows near the town, the verdant willows and sycamores that line the irrigation ditches, the wide-spreading pepper trees and tall eucalypts that border the Alameda in the southern part of the town, and the deep green shrubs, flowers, and palms of the central octagonal plaza gave no hint of that dormancy that characterizes the winter of our northern climate and of more southerly latitudes in South America. Compared with most South American cities of its size (its population in 1913 was but 11,000), it is beautifully kept, with clean streets, well repaired buildings, and a thoroughly businesslike air, whether we consider the management of its mines, the appearance and administration of its famous college and its still more famous school of mines, or the excellent administration of land and water rights. It has one of the two deepest mines in South America and the deepest in Chile (Dulcinea), enjoys the distinction of having had the first railroad, telephone, and telegraph lines in Chile, and one of the oldest opera houses, and the first gas works. For a time it was the chief center of copper production in Chile when as in the decades 1851-1860 to 1871-1880, Chile was the leading copper producing country in the world.

So distinguished a history is bound to be reflected in the traditions of the place, the pride of the people, and their public spirit; and one finds them on every hand in this old historic town. I watched the children leave school in mid-afternoon and a group of them appeared so swarthy and dark-skinned

that I asked one of the natives what percentage of Indian blood there was in the people of Copiapó. He was astonished at my question and replied that there was no Indian blood at all. When I told him of my impressions of color and head form not merely among the school children but among many of the people whom I had met he appeared still more surprised and told me that every well-informed man must know that there were no Indians and no Indian blood at Copiapó, that the people of the town were *Chilenos*. When I asked him about the ancestry of these Chileans he said that they were of Spanish descent and that, though there had been Indians in the valley and a certain amount of intermarriage, the Indian population had gradually disappeared. The fact is, of course, that the Indian population has been thoroughly mixed with the white. But it is interesting to learn that the native regards this mixture as a new type, and indeed I think it is. Of Indian customs and ways of life, ancient religious ritual, language, and so forth there is not a trace—in contrast to the almost barbaric mixture of Christian and Indian rites in northern Atacama or in highland Bolivia and Peru. Everyone speaks Spanish, the laws are impartially enforced, and there is no distinction in land tenure or government or social affairs on grounds of race or color.

One of the most striking features of Hispanic-American life is the persistence of given families in certain historical locations. Where there was a Díaz at the beginning of colonial life there you will find many Díaz families today. If a colonial grant was made to a Gonzales you will now find a Gonzales in possession of the land. Perhaps this would not strike a Frenchman or an Englishman as a matter of special interest, for the inheritance of landed property and reluctance to part with it, in short the fixed and stable quality of the old life of these countries, is somewhat similar to that which we find in Hispanic America or in Spain or Italy. In Copiapó it is illustrated by the family name of Aguirre. Francisco de Aguirre was the founder of Copiapó, and his descendants are scattered throughout the region today.

Having passed a week in Copiapó I had become acquainted through the officials of the mining companies and through

public officers with some of the leading families and was invited to a ball at the house of Señor Camilo Aguirre, a descendant of the conqueror. It was a most agreeable occasion for me, partly because I had never witnessed so elaborate an affair in what might be called a frontier town, and partly because of the festive spirit that reigned, for it was the birthday of the old gentleman and the occasion had brought out the leading families, all of them of marked cultivation and intellectually as interesting as any company of men and women to be found anywhere.

The influence which the Aguirre family wields in the region today and the distinction it enjoys are not based solely upon the achievements of the conqueror from whom the family has descended. They are based also and chiefly upon character and strength of purpose in the present generation. Though the landed estates of the older families give them marked distinction, it is in the government of the city and in what might be called the native trade of the town as distinct from the trade which the foreigner controls through ownership of mines and railways that their influence is chiefly based. In a book by Luis Silva Lezaeta, published in 1904, there is an account of the life of El Conquistador Francisco de Aguirre and (in an appendix) a list of his descendants. The exploits of this famous old Spanish captain (his portrait forms the frontispiece of the book) are among the most renowned of central and southern South America. Only four short years after Almagro went via Tupiza to Copiapó, Aguirre went this way also. Like Almagro, he crossed the high and cold Puna de Atacama, taking the route via Sapaleri, Chaxnanter, and Guayaques, to San Pedro de Atacama, where he arrived in April, 1540. Two months later he was joined there by Pedro de Valdivia who had taken the road of the desert, "Despoblado," from Tarapacá. Together they reached Copiapó in September.

In the "Valle de la Posesión," as Valdivia termed Copiapó, the Spaniards found a high state of cultivation based on characteristic Inca methods. When the Incas had effected the conquest of Copiapó they found there a scattered hunting population. The conquering forces cleared the dense thickets

of chañar and algarrobo that filled the lower valley, started irrigation, founded communal granaries, and distributed the population in orderly fashion along the valley in the linear manner of the Peruvian coast valleys. Between the distribution in the northern and southern valleys, however, an important difference obtained. In the Chilean valleys climate and topography restrict cultivation to lower altitudes: in the Copiapó valley cultivation stops a little above 4000 feet. The development of the Chilean valleys differed also in respect of external relations. Here the valley roads lead to no broad plateau, seat of a comparatively numerous population after the manner of the valleys of Arequipa and Arica that give access to the Titicaca basin. A little huanaco and vicuña wool came down from the cordillera, but the lower valleys were as self-contained and independent as the oases farther north.

On their arrival the Spaniards put into service both the desert route and that over the cordillera, especially the former, for the road of the cordillera presented greater difficulties and was closed for part of the year. The road through the desert was made possible by the existence of the line of springs and oases that closely define its course. Traces of the Inca road are still extant. Between Tilomonte and Copiapó, a distance of nearly 300 miles, it is described as running in a straight line and as being a band of cleared earth, about four feet wide and concave in section.⁴⁹ On either hand in certain portions of the road are ancient *pircas*, or stone walls, probably the remains of *tamberias*, or rest huts. On the passes traversed by the road are piles of stone, *apachetas* (p. 23), accumulated as the offering of the Indians to the guardian of the road, in much the same way as the Arab adds a stone "for good luck" to the piles near the oases.

The journey by sea in the early colonial period consumed an inordinate amount of time. The voyage from Callao to Chile, hugging the shore, usually took a twelvemonth or more. It was not until the early eighteenth century that a bold and observant mariner, noting the regular direction of winds and cur-

⁴⁹ Santiago Muñoz: *Jeografía descriptiva de las provincias de Atacama i Antofagasta*, Santiago, 1894, p. 127.

rents at a distance offshore, dared to sail far from land and thus made Chile in thirty days. The extraordinary nature of his feat is appreciated when we learn that he was promptly apprehended as a sorcerer and cast into prison until the natural basis of his skill became understood! The road of the desert then provided the essential connection between Peru and the new province of Chile. As the Lima-Buenos Aires road created the settlement of Salta (see Chapter IX), so the desert road to Chile led to the foundation of a number of Chilean settlements chief among which were Serena and Copiapó. Juan Bohon, one of Valdivia's followers, erected a fort in the Copiapó valley, the first important valley beyond the great desert stretch, and, as an intermediate station between this point and Santiago, established Serena in 1544. But he enjoyed his extensive grant for a short period only. Five years later the Indians rose, sacked Serena, killed Bohon and his dependents, and destroyed the fort in the Copiapó valley. Bohon's encomiendas were conceded to Francisco de Aguirre.

Aguirre promptly rebuilt Serena and established himself in the Copiapó valley on the site of the present town. Here at a convenient distance from his rivals to the south he set to work planting vineyards and introducing various Spanish products to which the climate was admirably adapted. Later Valdivia appointed him Governor of Tucumán; for the limits of Chile, as originally defined in utter ignorance of the geography of the region, extended over the Andes onto the eastern plains. The simultaneous exploration of vast territories from different starting points led to innumerable clashes among the early colonists. Aguirre's new appointment provided one. Nuñez de Prado, acting under the orders of La Gasca in Peru, had already founded the settlement of Barco in Tucumán. His venture proved unsuccessful; the city had in a short space of time been moved three times; and its unhappy citizens welcomed his deposition at the hands of Aguirre, who arrived in 1552 with resources from the Copiapó valley. The next year Aguirre transferred the city to the site it now occupies, changing its name to Santiago del Estero del Nuevo Maestrazgo. Thus an Aguirre has the distinction of having founded the first and oldest city

of Argentina. There he laid the foundations of agriculture on a satisfactory basis. The grateful citizens testified "he has spent and spends many pesos of gold in the provisioning of this land, for he has a good property in the 'valle de Copayapo' from whence he has provided and provides all the necessities for the sustenance of this city."⁵⁰

At first the grants of land in the Copiapó valley were quite vague. Some titles gave the owners rights that extended from the sea to the cordillera or from one quebrada to another. So great was the resulting confusion that the Audiencia Real organized a commission charged with the duty of straightening out land titles where claims conflicted and of fixing the limits. In 1712 the commission gathered together all the titles it could find, and various miscellaneous papers as well, and set definite limits to the adjacent grants.⁵¹

THE SITUATION OF COPIAPÓ

The geographical situation of Copiapó has given it some great natural advantages. It is in a region of increasing rainfall southward, though the annual precipitation is still extremely small. As we have already pointed out (pp. 47-48) this change is coincident with a topographic change. Instead of flat-floored basins rimmed by gently-sloping alluvium that appears to be flat in a distant view, we have here a broken or accidented country that lies at a higher elevation above the sea and is drained by a series of wide-branching tributaries taking their rise in lofty mountains (snow-covered most of the year) in the main chain of the Cordillera of the Andes. The trails naturally follow the watercourses to a great degree, and the convergence of the wide-spreading branches of the Copiapó River in the cordillera tends also to converge the trails upon the valley at Copiapó.

Located in this wise, the town attracts trade along the main north-south valley, which is developed as a true valley and not as a string of basins in the manner of the drainage basins of the

⁵⁰ L. S. Lezaeta: *El conquistador Francisco de Aguirre*, Santiago, 1904.

⁵¹ C. M. Sayago: *Historia de Copiapó*, Copiapó, 1874, p. 85. This most interesting work has been extensively used in preparation of the section on Copiapó.

nitrate desert on the north; and it tends also to draw trade from the coast, naturally tributary to it, and from transmontane Argentina. In the days of Aguirre and Valdivia, as in the time of the Incas just before, Copiapó was an outpost of the conquerors' settlement in Chile. When the country farther south became settled, Copiapó continued to be a great frontier town; but this time it was a frontier facing north, toward the desert, rather than a frontier that looked south toward the richer land that was to become the heart of Chile at a later time. To change its outlook, or orientation, in this manner was also to change its life; and this happened again and again not only with respect to its frontier position but also with respect to the whole industrial change that overtook Chile in its national development. Copper, nitrate, the railway—each has meant a complete and revolutionary change in the fortunes of Copiapó.

The population of the town changed rapidly in numbers with every change of fortune. At one time the Copiapó district counted over twenty thousand souls and Copiapó was one of the busiest cities of South America. This was at the height of the silver and copper mining, nearly three-quarters of a century ago. It also enjoyed prosperity because of its trade with the transandean settlements, in what is now northwestern Argentina. A very famous trail runs eastward from Copiapó up to the headwaters of the Jorquera River; thence it passes immediately south of the peaks of San Francisco and reaches the basin of Fiambalá, through which it runs southward to Tinogasta with branches to Catamarca, Santiago del Estero, San Juan, and other frontier towns of Argentina (consult Figure 1).

Lying on the trails and roads to the nitrate fields of the north and the center of a great mining region, Copiapó later developed a cattle business with the Argentine. The herds gathered at San Juan, Catamarca, and Tucumán are driven for twenty-four or twenty-five days over the mountains and down into the valley of Copiapó. The cattle are brought in to the number of 12,000 yearly and are driven across the mountains from September to May, most of them in May before the passes are closed with snow. They are mixed breeds, able to stand the trying weather and bad going of the mountain country. Upon

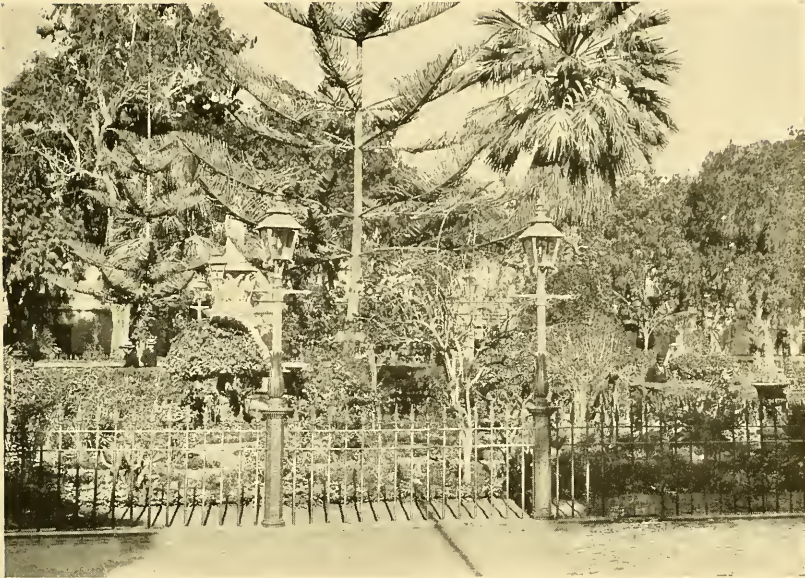


FIG. 31



FIG. 32

FIG. 31—Central plaza at Copiapó. The compact mass of trees and shrubs is irrigated by water from the Copiapó River.

FIG. 32—Street scene in Copiapó showing the one-storied houses. The tall building on the right at the farther end of the street is the Hotel de Atacama, one of the two-storied structures in the city.

arriving they are fed for several weeks or months on green alfalfa and then sold in remittances of a few or many to tributary mines and towns.

Accustomed as we are to the present boundaries between Chile and Argentina, it sounds strange to hear that the north-western settlements of Argentina had their first connection with southern Bolivia and desert Chile. There are two reasons for this, the one historical, the other geographical. The Viceroyalty of Peru at one time embraced most Spanish possessions south of the Isthmus of Panama and west of the "line of demarcation" between Spain and Portugal in western Brazil. Lima became a focus of commerce and authority. An old trade route ran southwest of Lima to Abancay, Cuzco, La Paz, Tupiza, Salta, and Santiago del Estero. It was a part of this route that Almagro took on his way to Copiapó. We have seen that Aguirre came down in the same fashion rather than by what appears to be the easy route of the sea had there been ships or the materials for building them. The first settlers came in the same way and established themselves in fertile valleys within the eastern border of the mountains or on the edge of the adjacent plain. Under these circumstances it was natural for the people of Copiapó and other towns farther south to look toward the country east of the mountains as a field of colonization and settlement. Though the mountains raised formidable physical obstacles, they had to be overcome from the first. What seems at first sight a more natural connection with La Plata would then have been an unnatural relationship, for a broad band of plains country beyond the mountains, that is east and south-east of them, lay between, and it was sterile, sandy, desert waste. The transcordilleran province of Cuyo, what is today the provinces of San Juan, San Luis, and Mendoza, pertained to the government of Chile until 1776. It was not until 1778 that the Plata region could be reached by sea, for the agreement between Spain and Portugal restricted commerce on the Atlantic to the Spanish possession of the West Indies and west of the line of demarcation and permitted neither Spanish ships to seek ports nor colonists to seek fields of settlement by way of the South Atlantic.

When railroad connections between the towns of northwestern Argentina and the Plata country had been established, the mountain trails declined in importance. Trade from one side of the Andes to the other became feeble and irregular and was limited to specialized products, such as wool, imported manufactured articles, live stock driven over the trail to its destination, and the like. This process, together with the drawing off of labor to more distant mining communities and to the nitrate fields, has caused the population of Copiapó to fluctuate from decade to decade by substantial amounts. In 1865 Copiapó had more than 13,000 people; in 1875 it had less than 12,000; in 1885 less than 10,000; and in 1895 but 9300. It rose to nearly 11,000 in 1913 but declined again to 9834 according to the census of 1920. The estimated population on January 2, 1922, was 9797.

PHYSICAL BASIS OF LIFE IN COPIAPÓ

Not merely Copiapó but all the other towns of Chile present a singularly interesting aspect of city geography. Outside a few large cities, such as Lima and La Paz, I have been greatly struck everywhere through the Central Andes, the Desert of Atacama, and northwestern Argentina, with the extremely close dependence of towns upon the environing country, the trade routes, the trails, the sources of water supply, and the rural hamlets. It is a connection far more intimate and substantial than anything we see in our country today, and I cannot but think that it has had a large effect upon the stability of life in the various countries of Hispanic America. Though revolutions often take their rise in distant places far from the central seat of authority, it is the large city that has been the breeding place of most revolutionary plans. Certainly it is the place where the revolutionary power has to be put into effect and where laws good and bad originate to influence the political life, the government, the foreign relations, and perhaps the foreign trade of the country. But a revolution in Hispanic America is not at all the thing we have in mind in speaking of the French Revolution of more than a century ago, or the Russian Revolution of our time. In South America it affects

but a few centers, a limited number of persons, a very thin layer of the people if I may so put it. For the rest, the life of the communities of Hispanic America goes on unaltered by revolutionary changes. The seasons, the crops, trade, social gatherings, the community organization—these are the things of outstanding importance. Newspapers and letters do not speedily convey information either from the outside world or from distant places in their own country; and over most of South America the press services are most inadequate, whatever may rightly be said of the extraordinarily good services of the largest towns like Buenos Aires and Rio de Janeiro. The frontier communities are immeasurably isolated and provincial, ingrowing, self-governing, substantial, rooted to the soil, permanently related to natural conditions—in short, *established*.

All this is reflected in the census statistics. Take the figures from 1865 to 1920 as given by the Central Statistics Bureau of Chile. We find that there had developed in that period but two towns of over 100,000—Valparaíso with 182,422 and Santiago with 507,296—comparable, that is, with the population of Worcester, Mass. (179,754) and of San Francisco (506,676). Of towns from 20,000 to 100,000 inhabitants there was but one in 1865. By 1907 six of them had developed, with a total population of 221,000. Of towns with 5000 to 20,000 inhabitants, 41 had developed by 1907; those with 1000 to 5000 inhabitants numbered 170. The total population of these chief places was 1,408,000 in 1907; but of rural towns there were 4884, with a total population of 1,247,000. There are substantially 5000 towns, if we count the smallest as well as the largest in all of Chile; and of these only about fifty have a population greater than 5000, with an aggregate population of 1,000,000 in round numbers, or about 25 per cent of the total population of the country. When we consider the artificial character of many of the towns, for example the nitrate port of Antofagasta with 32,500 people in 1907 (51,500 in 1920) and of Iquique with over 40,000 in 1907 (37,400 in 1920) and the importance of mining carried on chiefly by foreign capital and enterprise, we can then realize the close dependence of most other Chilean towns upon the soil and the cattle production of the country.



FIG. 33



FIG. 34



FIG. 35

FIG. 33—Panoramic view of the city of Copiapó, Chile, looking south toward Paipote. It is situated near the southern end of the Desert of Atacama. It is a one-storied town, spread over about one square mile of land and with a population of 10,000. About it and both up and down valley are irrigated gardens, fields, and pastures. Its prosperity depends upon a few winter showers, the flow of the Copiapó River, and the exploitation of the mines in the surrounding mountains.

FIG. 34—The upper valley of Copiapó, above Paipote, looking south. View from the piazza of El Rancho Florida. The irrigated valley floor forms a strip of green in the midst of barren mountains and basins in the Desert of Atacama.

FIG. 35—Panoramic view of Vallenar in the Huasco valley, Chile. At the left, one is looking eastward up the valley; at the right, southward across the valley. (These three photographs were taken by Professor Bailey Willis, on the Chilean Earthquake Expedition of 1923, Carnegie Institution, and are reproduced herewith by special permission.)

We can then also realize the stability of the natural life of the several communities of Chile. We speak now of the economic and social and political life that is domestic and not of that which has to do with the national government or with international affairs or with matters of general policy.

The Copiapó-Vallenar region lies on the border between two distinctly different regions, the one being central Chile, where most of the people of Chile are found, the other the nitrate desert of the north. Set between these is the borderland region, where the rains are greater than in the nitrate desert but still so uncertain as to give a truly desert stamp to settlements, trails, communications, products and impose a marked degree of isolation. From Copiapó northward every government official gets a certain percentage of his salary extra as a "gratification," or bonus, because living is more expensive than in the south. Copiapó thus acquires the special character of a frontier settlement that is at the same time a desert settlement.⁵²

NATURE AND ORGANIZATION OF DESERT SETTLEMENTS

Each populated desert valley is a geographical experiment. In every one I know there are distinctive features of government and social organization, yet they are all alike in that the attention of the entire community is centered upon a single feature—the river, which is vital to its life and happiness. Even when a railroad at last links up such a valley with the rest of the world, it is a connection not marked by the innovation of express trains and skyscrapers. Riding from Vallenar to Copiapó one takes a train consisting of four cars and an engine. One of the cars is for mail and express, the second carries wood, a third water for the engine and for the dry stations along the line, and it is only a fourth car that carries passengers.

There is a further reason why the life of a desert valley is so intensely focused upon the river that sustains the group.

⁵² It is the same in the wet and cold far south of Chile in the Magellan region, and similar conditions exist in other countries where extreme climatic conditions are found on distant frontiers of civilization. The scale for the additional salaries paid by the State to officials in Swedish Norrland is determined according to the diminishing degree of light during the dark period of the year. (H. W. Ahlmann: *The Economical Geography of Swedish Norrland*, *Geografiska Annaler*, Vol. 3, 1921, pp. 97-164.)

Practically all oasis settlements are small. Rarely do they exceed more than a few thousand inhabitants, and they range downward in size to the smallest groups of a half dozen families or a single family, as, for example, at Monte la Soledad in the nitrate desert east of Iquique (see p. 37). This means that there is no superstructure of society or business or professional men. If there is a doctor he may be the only one in the village or the valley. A few so-called lawyers for the drawing up of legal papers, a few government officials, one or two exceptionally "rich" men—these complete the class that furnishes leadership in the valley. Their life would be lonely and isolated if it were not merged in the common life of the community, as indeed it is. The paraphernalia of the modern city is absent. There is no leisure class, there are no social or economic parasites. Every man is a worker, and the most prosperous and the most powerful politically or financially are only a step removed from the river which is the source of life to all.

The self-contained quality of such a desert valley is not one that is achieved by striving. It is assumed almost unconsciously. It is interwoven in the traditions of the place. More than that, if the valley is in Hispanic America its life springs naturally from the traditions of the race no less than from the geographical environment. The first Spaniards who came to desert Chile brought with them a knowledge of the technic of irrigation. They found established on the spot a people whose immemorial practice had been to irrigate the land for agriculture. For example the Indians of the Copiapó valley had diverted the river, had watered the valley floor and the bordering terraces by irrigation canals—in short, had already established themselves harmoniously with nature before the Spaniards came.

The simpler life of a desert community, its awareness of the ultimate sources of its prosperity, and the absence of parasitic industries are in striking contrast with the conditions that obtain in a modern city, where the machinery of life is so complicated that the consumer is many times removed from the producer. In the latter case there is a dependence upon economic and financial agencies whose workings are too compli-

cated for the mind of the public. The consequence is that the government comes in and is eventually as complicated as the life it controls. We have seen this in our own time, and the extent to which the operations of government are carried with each advance in industry and general development is so great as to raise the question whether government may not become so complicated that it may break down. We are not here concerned with the question, non-geographical in character, as to whether such a condition is inevitable or helpful or may profitably be replaced by some other. We wish simply to picture a condition that brings about a growing dependence of a whole people on the government when they look to it to manage everything for them.

In no desert valley in the world can be found such complicated situations as these, and yet the stringency of government is just as great or even greater in so far as the control of the vital question of water is concerned. In all other matters there is a freedom of action on the part of the individual and an absence of restraint in striking contrast to larger communities.

TAKING CHANCES WITH THE RAIN

If Copiapó had no rains at all and if it enjoyed a regular supply of water from the Copiapó River, there would long ago have been an easy adjustment to natural conditions on the part of the population. That rains do come occasionally and that the river is as capricious in its flow as the mountain streams that feed it are conditions that create the chief inducement to gambling with nature. The year 1914 had more rainfall than had been known for many years (27 mm.). In 1904 and 1905 there was heavy rainfall, for it rained six or seven times during the winter season of May to July, and a rainy year is recorded if but two or three showers fall (see Table I, p. 44). In 1888 the first shower of the year came at the end of April, and a heavy shower on the 13th of August. According to the history of the weather bureau at Copiapó, and of the mining companies, the Copiapó River did not reach the sea before 1888 so far as the records tell. Dependent chiefly

upon mountain snows, the river comes down past the town each year and may be counted upon to water a certain amount of irrigated land. The Rio Algarrobal (latitude 28° S., or between Copiapó and Vallenar) last reached the sea in 1906. For years it had terminated above the pueblo Algarrobal, but in the four wet seasons of 1902–1905 inclusive it flowed to the end of its valley.

When I visited the Copiapó valley in 1913, after an earlier journey through the nitrate desert on the north, the region had suffered for several years from one of the most severe droughts in history. The floor of the river channel was as dry as the neighboring country. There were salt incrustations that made white patches against the brown and yellow of the bordering desert and patches of dark-green brush or scrub gathered for firewood; and only as one approached Copiapó did the cultivated land appear, rich where there was water and quite barren upon those tracts for which a sufficient supply of water did not exist. On every hand I heard with what difficulty enough water was secured to keep the alfalfa meadows from drying up and the cattle from starvation.

Though there is more water at Vallenar, in the Huasco valley 100 miles south of Copiapó, the same complaints were made there. It was predicted that rain would surely fall, because no rain had fallen for three years in succession. One day great masses of black clouds came rolling up from the south, rain was confidently predicted, and telegrams were sent to absent owners at Santiago. It was a novel experience to find water so important that messages are sent whenever it looks as if it *might* rain! But the clouds dissolved in the late afternoon, and I was disappointed on leaving to have missed a rainstorm in famous old Vallenar. At the suggestion of one of my hosts I left my future address, so that he might telegraph me news of the first rain!

A single heavy shower benefits pastures and fields and brightens the outlook of hundreds of people. Two showers bring a year of plenty, and three or more showers make the year memorable, if indeed they do not bring floods and greater disaster than several years of drought.

FLOODS OF DESERT BASINS

The floods of a desert basin that is self-contained are limited in size and in devastating effect because the watershed is limited. In a desert country there are as many separate floods as there are separate basins. When the basins coalesce, however, it is the sum of all the floods that reaches the main valley. Not merely this, the run-off in such cases is much more rapid because there is a succession of channels down to the main through-flowing stream rather than a series of bordering alluvial flats into which all the floods may readily sink.

It is precisely this condition which is encountered in the Andes in the region of Copiapó (cf. pp. 47-48). The rainfall of the high mountain zone is sufficient to bring about a normal organization of stream courses on both sides of the Andes, and instead of the interior basins of northwestern Argentina, southwestern Bolivia, and northern Chile we have here wide-branching tributaries and streams that flow through to the sea (Fig. 86). The relation of such an organized drainage system to floods is not merely of technical interest; it is immensely important to the people who live in the valley below.

Naturally a more constant stream like the Copiapó River calls into being a larger settlement, and in general we find that streams and settlements in desert regions are proportionate in size to each other. This means that if damage is done because of the great floods that come down the Copiapó valley, or any valley so situated in relation to the snows and rains of a high mountain belt, it will be on a far larger scale than in the ravines on the drier western mountain border and interior basins of northern Chile.

It is the fate of desert communities that they should be devastated by the same agent to whose gentler operations they look with such delight. To take a specific example, on May 21, 1905, snowstorms raged in the cordillera, and the Copiapó River rose "enormously," doing no end of damage throughout the whole middle and lower valley, cutting the railroad below Copiapó, and sweeping away a bridge. Alfalfa fields were filled with mud and clay, tracks and roads were

washed away, and traffic was quite suspended. The thick muddy water came pouring down the valley, modifying all the meander turns and having regard for neither fields nor houses, both of which were greatly damaged in Copiapó. On July 14 of the same year severe rains followed, the storm lasting ten hours. A cart road was destroyed; the Chañaral railroad was washed out, and it was months before the service could be restored. Not only the higher mountains but the foothills were covered with snow to so low a level that no one was able to recollect a similar occurrence. With the snow and rain the river continued to rise even into September. In October the railway from Copiapó to Caldera was broken, and it required a month to re-open the line; for the nature of the flood required a new course to be found to escape a renewal of the disaster. At a time when it was particularly needed the community was without a vital service. The break in the line found Copiapó supplied with flour enough to last for only eighteen days. The vineyards and fields were ruined, a covering of mud was laid upon the barley and alfalfa fields so that the growth of these crops was stopped, and the mud, baking under the desert sun, made cultivation difficult. Even the mails became irregular owing to the scarcity of animals, because the merchants had taken all the available animals in order to convey their merchandise. Barley and forage rose to famine prices and were almost unobtainable. Labor became scarce, the coal question serious, and during this time of stress and want the river still continued to harass the fields and houses within reach so that the end of the disaster was still in doubt and every mind was filled with anxiety.

The floods continued into December with greater increase of water. The irrigating canals were cut off or sediment was deposited in them with the consequence that the full force of the water acted upon the valley. At length defenses of wood and bags of sand were laid in place; but these were torn away, and corrals and houses tumbled into the river at Tierra Amarilla above Copiapó. It was necessary to call on troops stationed in the town to repair and strengthen the dike, and their work was hurried by news from up river that twenty houses

were destroyed. Mines were shut down because of lack of provisions, fodder, and labor. With roads washed out, fuel and vegetables could not be brought down valley, and prices rose even higher. By January 2, 1906, there had been such an enormous increase of water, owing to the unusually hot weather in the cordillera, that half of Tierra Amarilla was swept away. The government sent a company of troops and hydraulic engineers from the Public Works Department, and only by their combined efforts and the work of the citizens was the lower part of Copiapó saved. A mile and a half of flood-plain margin was torn away between Tierra Amarilla and Copiapó. Hundreds were rendered homeless, and others obliged to live in hastily-made shanties on higher ground at the border of the valley. Under these circumstances the government was called upon to send relief to the sufferers; and this, together with money collected from the citizens, put the town in order again. In addition the government granted \$400,000 for the construction of new roads with power to expropriate the private lines.

When the rain fell not too rapidly but just at the rate at which the soil could absorb it, as in May, 1851, it was a matter of observation in a letter of the mine managers of Copiapó to their English owners; and if cloudy weather followed, thus slowing up the rate of evaporation, it was likewise a matter of comment, just as in Greek agriculture when Hesiod commends the rain that falls so that the water stands at the level of the hoofs of the oxen, neither more nor less.

DEPENDENCE ON THE RAINS

The two elements of greatest importance in the study of the relation of the people to water supply in this border region are the local showers and the distant mountain snows. The showers are nature's gift to poor and rich alike; the snows, melting, discharge by way of rivers, and river water can be used only by the landowner who lives on the valley floor. Furthermore, the larger the estate the more water it is entitled to use; hence a greater disparity between the financial condition of the small

and the large landowners in years of low water. The resources of the rich enable them to weather the temporary difficulties which years of drought inevitably bring. By contrast, the poor landowner may be forced to sell his farm and stock at just the time when they bring least. To him the droughts may mean not only distress but ruin.

In earlier years, when there was a purely local market for farm products, the rains were not an unmixed blessing. The owners of hired troops of mules, the cattle importer, and the miner were all benefited, since their stock found free forage. But the landowner who made a business of renting pasture or selling hay found his income reduced, because the lower prices of wetter years more than offset the greater product. Since the prices of all merchandise were largely controlled, in the pre-railroad days (before 1851), by the rate of transport from the coast ports, and this in turn by the abundance of free pasture and the price of hay, the wet years always carried the advantage of cheaper goods, and this advantage was shared by all. Those who had forage to sell, therefore, gained most in years of moderate dryness, when there was neither free pasture nor abundance of water for irrigation.

At the present time the nitrate industry alters this condition. Its steady demand upon the alfalfa meadows for the thousands of mules that are required for the caliche carts maintains the prices at a higher level, and most years of rain are now marked by a much higher level of prosperity for the landed proprietors. This in turn helps the poor laborer, the vagrant shepherd, and the small landowner who in former times was often pushed to the wall. Life has therefore become easier and safer; the former waste in years of rain and the distress in years of drought have been displaced by organized commerce in response to the steady market at the nitrate works of the desert. But the people have not in any sense lessened their dependence upon the rains. In fact, they have greatly increased it. A new industry and the general organization of commerce in which the railroad plays a large part have merely turned their dependence into new channels.

In the wet years, imported cattle from Argentina winter in

the hills and are driven down to the valleys ready for the market. In dry years they arrive lean and weak after their long journey across the lofty desert mountains and must be fed on rented pasture in the alfalfa meadows of the valley ranches. When dry years occur in succession the prices of forage may rise faster than the prices of meat, since the owner's draught animals are his first care. As a result the drovers stop their importations, for with rising prices the small buyer who is continually becoming poorer at last is unable to buy meat at all. If the dry period continues, mules may be driven from Chile into Argentina, there to winter on cheaper pasture until the return of normal conditions in the desert.

Formerly the mining industry (described in detail in a succeeding chapter) absorbed not only the chief part of men's energies in the Copiapó region but also most of the products. Cattle were then imported from Argentina for the mines, just as they are now imported for both the mines and the nitrate fields farther north. Great troops of hired mules were employed by the mine owners to carry copper and silver ores to the coast ports. Both mules and cattle had to find subsistence in part on the desert upland, where short grasses spring up after the winter rains. In the history of the mines there are many instances of distress owing to the poor state of the pastures. Exploring expeditions were early sent out to discover new routes along valleys where showers had been reported by travelers, and in at least one instance a new route led to the development of a new port as short-lived as the pastures to which it owed its origin. When a period of dry years set in, all transportation had to be stopped, the ore accumulated at the mines, and chartered ships were sent back to Swansea either empty or half loaded. Thus Chilean mining company dividends were passed more than once at London because of the lack of a few showers in Chile.

THE STRUGGLE FOR WATER: THE LAW OF THE TURNO

It is the way of men everywhere to form stringent rules and regulations for the social group and to put into force a special

régime when face to face with disaster. We are led to think of a desert valley that has twelve thousand people, dependent to a great extent upon mining, and normally supporting four thousand people through irrigation alone, as living in a state of tension. Even after railroads have been built and life is organized as now, the rains and the floods cause so violent a shock to the economic structure of the valley that social and political changes immediately occur calling for emergency measures quickly and rigorously applied.

If the traveler come to such a valley in the midst of a drought, calamity seems scarcely to be afoot. The life is quiet, even quieter than usual, in spite of the general anxiety, though if one knows where to look and how to inquire he is aware of the rigorous application of a law to the execution of which the government bends every effort. This is the law of the *turno*. It means that each man must take his turn in drawing off water from the river for the irrigating canals that supply his fields. The hour in which he may open the head of his main feed canal is indicated, and the number of hours that he may take water from the river is explicitly stated. He must then close his canal and wait for his next turn. The length of time that elapses between turns is dependent upon the flow of the river. All the people of the valley must share in the general distribution of water. If those down the valley receive no flow at all they make due complaints to the authorities, and there may follow a readjustment of the *turno*.

An irrigated valley thus becomes a social unit operating under a system far more rigorous than that which obtains even in the crowded city. The application of the *turno* to the water is like the traffic policeman's signal to a line of vehicles, and, just as the violation of the policeman's signal is considered to be the chief offense of a driver, so the violation of the *turno* is the chief offense of the farmer. The greed of one person here in a very direct way means loss to a neighbor; and it is a loss that amounts to theft, for the one who takes more water than is his right is taking that which the law has already decreed should belong to his neighbor. It is really a communal organization in which individual ownership of property in water

is unknown. The river and its water supply belong to the community; whatever the river does is the concern of the whole community. But for the river there would be no community. Under these circumstances if government means anything it means the care of the river, which is the source of life. As a result there is a state of potential anxiety almost constantly. As a further result measures are devised for the control of all activities that bear upon the river. The government is ready to step in at any moment and exercise its right to act for the general good. It is as if a city like San Francisco, having suffered from earthquake and fire because it lies in a belt that is subject to earthquakes, should organize the machinery of government in such a way as to provide for the coming into force of special laws and the organizing of a special police to meet the emergency conditions that might arise should another earthquake take place.

While the turno in one form or another is a subject for almost yearly consideration, there is more than one historical example of quite special interest owing to severe drought. We may take the case of 1877 for detailed examination. The extent of irrigated land at Copiapó is from 4000 to 5000 cuadras, a cuadra being 125 meters square; and it runs in narrow tracts on both sides of the river from 75 miles up valley and from 10 to 15 miles down valley. I traversed the valley to see under what conditions water was distributed, talked with members of the city administration regarding the legal aspects of the use of the water, and from one of the mining companies obtained two striking documents bearing the seal of the "Municipalidad de Copiapó." The texts are reproduced photographically herewith (pp. 124, 126). The first, that bears the signatures of the proper city authorities, is dated March 27, 1877; the second is dated May 2 of the same year. They enable one to obtain an intimate view of the workings of the law of the turno. The first one states that there is appointed a commission of *alcaldes* to meet in those parts of the valley most interested in irrigation for the purpose of changing the law of the turno in order to avoid the many difficulties and embarrassments into which the people of the valley have fallen and the

insecurity that they feel in the present system of water distribution. Provision is made for a meeting of delegates from the various irrigated districts in the valley and for alternate representation in case a proprietor or tenant is unable to attend. Voting is proportional to the size of an estate and the "hours of water" which correspond thereunto. Proprietors of small patches of land are permitted to consolidate their votes in order to obtain representation.

The second document is a report approved by the delegates named for the general meeting, a report that is designed to change the law of the turno in the Copiapó valley. The first part has to do with losses in time sustained through delay in the arrival of the water from up valley owing to seepage and the natural time it takes for upstream water to reach a point downstream when the river bed is dry and must be filled before a flow begins. The second part establishes conditions for the taking of water. Four periods are established in which to calculate the loss of each district: the turno of January 1, that of April 1, that of July 1, and that of October 1. All persons using an irrigating ditch are under obligation after taking out their share to leave the inlet blocked off, under penalty of a fine of ten pesos for each offense. All industrial establishments are to take water for the operation of their machinery when the flow from the city reaches the district in which they are located and must well secure the inlets and commit no abuse, under pain of a fine similar to that indicated above. Attention is called to the lack of a law for the use of the water in industrial establishments of the valley and at the railroad stations; and to the need of "repairs" to the river bed itself in order presumably to conserve the flow. Especially significant is Article 6, which proposes that the change inaugurated by the resolution in question should be for one year by way of experiment, with the implication that abuses or defects would be remedied by new measures.

The procedure which these two documents indicate must be repeated whenever the disposition of the cultivated land or increase and decrease of the inhabitants or changes brought about by floods have so altered the irrigated land in relation

to the ditches and the river as to make the established distribution of water unfair. When a man organizes a farm, that is clears it of brush and digs a ditch to it, he inquires of the "judge of water," a special official whose business it is to look after water disputes, as to how much water he may take and obtains a decision. In good years each farmer may take as much as he likes; but when the river is low the judge of water has to settle a host of cases, for disputes are of almost daily occurrence. Feuds arise and grow the more bitter, because the valley is restricted in population and because families are intimately related by village or social groups scattered up and down the valley. The quarrel of one thus becomes the quarrel of the group to which he belongs.

Said the manager of one of the mining companies at Copiapó in 1838, a year of particularly severe drought: "It would be difficult for any one who has not experienced it to believe in the robbery and quarreling constantly on foot with respect to rations of water in this extraordinary and desert district, along the whole course of the valley from the town to the cordillera, a distance of ninety miles—all the lands being dependent for irrigation upon a little contemptible stream of water whose volume at any one point is barely sufficient to fill the weir of an ordinary flour mill.

"Notwithstanding the regulations that have been made by the authorities—and heavy fines imposed on infringements—such are the difficulties of proof and such the localities of the district that abuses can be practiced with impunity. . . ."

On more than one occasion I got myself into an embarrassing position on account of seemingly harmless questions about water rights. I soon found that a social guide was needed—one who could tell me who were friends and who were enemies. At times it was necessary to exercise great care in receiving various officials and townspeople who were kind enough to call upon me, lest there should be formed an uncongenial group. It would be difficult for A to join B in polite explanations when A's servant had but lately broken B's servant's head. B would not feel nearly so badly about the broken head as about the alfalfa field that would now be ruined on account



Señor:

Copiapó, marzo 27 de 1877.

La Ilustre Municipalidad de Copiapó en sesion extraordinaria de 5 del presente, acordó nombrar en comision a los señores alcaldes para que se sirvieran convocar a una reunion a los vecinos del valle interesados en el riego, con el fin de tomar las medidas que fueren mas oportunas para cambiar el órden de los turnos en el regadio, y hacerlo, si posible fuere, de abajo para arriba, porque se hizo presente, por el señor Intendente, que tratando de mejorar el actual sistema que se tiene en práctica de salvar las numerosas dificultades que se presentan y disgustos que hacen de hacer efectivo el derecho de cada cual, y saber con entera seguridad quienes son aquellos que verdaderamente faltan, habia conferenciado con algunos interesados, con el celador mayor de aguas y otras personas convecedoras de lo que al presente pasa, sobre la conveniencia que resultaria si se adoptase el sistema de regar de abajo para arriba y que por todos habia sido aprobada como una medida justa y equitativa que pudiera dar fin a las cuestiones que diariamente se suscitan.

Los señores alcaldes, dando cumplimiento a su cometido, se constituyeron en sesion el día 21 del actual y celebraron los siguientes acuerdos:

1 ° Para llevar a efecto el acuerdo municipal de 5 del presente mes, la comision acuerda pedir a los señores subdelegados del valle se sirvan convocar a todos los interesados en el riego a una reunion que tendrá lugar ante ellos para proceder a nombrar delegados por cada uno de los distritos regadores, para que éstos, de acuerdo con la comision municipal, puedan discutir y adoptar las medidas que fueren mas oportunas para cambiar el actual sistema de turnos y hacerlo de abajo para arriba, previéndoles que en aquellas subdelegaciones en que hubiere mas de un distrito regador los inspectores serán los que dirigirán la reunion, teniendo siempre especial cuidado de que ningun distrito quede sin representante, y que todo cuanto se acordase en la reunion o reuniones de los delegados con los comisionados municipales, será sometido a la aprobacion de los propietarios o arrendatarios de fundos una vez terminado el trabajo y nunca podrá llevarse a efecto sin haber obtenido éstos su asentimiento.

2 ° La reunion para la eleccion de los delegados tendrá lugar en la forma indicada, el día 15 de abril del presente año a la 1 p. m.

3 ° Aquellos propietarios o arrendatarios que no pudieren concurrir personalmente podrán hacerlo, o bien por medio de apoderados, o bien remitiendo su voto por escrito.

4 ° En la reunion para elegir delegados, cada propietario o arrendatario de fundo, tendrá tantos votos cuantas fueren las horas de agua que le corresponden.

5 ° Los propietarios de fundos pequeños podrán reunir sus votos con el fin indicado en el precedente acuerdo.

6 ° En la ciudad la reunion para la eleccion de delegados tendrá lugar el día y hora indicados, en la sala municipal y ante la comision nombrada.

7 ° La primera reunion de los comisionados municipales con los delegados, tendrá lugar el 29 de abril próximo entrante a la 1 p. m. en la sala municipal.

Al señor

Don Tomas Paredes
B

Guillermo Matte
Francisco
procurador

Copiapó, March 27, 1877

Señor:

The Illustrious Municipality of Copiapó, in extraordinary session on the 5th instant, resolved to appoint the mayors as a commission with instructions to call a meeting of those residents of the valley who have interests in the irrigation system, for the purpose of taking the proper steps toward changing the order of rotation in the use of the water, and, if possible, to make the rotation in upstream order: inasmuch as the Intendente has pointed out that, in an effort to improve the present system so as to avoid the numerous difficulties that are encountered and the unpleasantnesses which spring from the attempt to secure each irrigator's rights and to know with certainty those who truly lack water, he had conferred with some of those interested, with the chief water master, and with other persons familiar with the present situation, regarding the advisability of adopting an upstreamward order of rotation, and that all had approved the plan as a just and equitable one which might be expected to put an end to the difficulties that were daily being presented.

The mayors, carrying out their instructions, met in session the 21st of the present month and adopted the following resolutions:

1. In order to carry out the resolution adopted by the Municipality on the 5th of the present month, the Commission resolves to ask the representatives of the *subdelegaciones* of the valley to call together all those persons who have interests in the irrigation system, for a meeting to be held before them [the above representatives] for the purpose of naming delegates from each one of the irrigation districts, who, with the approval of the municipal commission, should proceed to discuss and adopt appropriate measures for altering the present system of rotation and making it in upstreamward order; advising them that in those *subdelegaciones* in which there are more than one irrigation district, it shall be the duty of the inspectors to direct the meeting; great care being exercised also that no district be without a delegate, and that everything done in the meeting or meetings of the delegates with the municipal commissioners be submitted for the approval of the proprietors or renters of farms as soon as it has been agreed upon, and that no measure be put into effect without having obtained their consent.

2. The meeting for election of the delegates shall be held in the form indicated and upon the 15th of April of the present year at 1 o'clock P. M.

3. Those proprietors or renters who are unable to attend personally may do so either by proxy or by sending their votes in written form.

4. In the meeting to elect delegates, each proprietor or renter shall have the number of votes corresponding to the number of hours in which he has the use of water.

5. The proprietors of small farms may combine their votes for the purpose mentioned in the preceding resolution.

6. In the city the meeting for the election of delegates shall be held the day and hour indicated above, in the municipal hall and in presence of the appointed Commission.

7. The first meeting of the municipal Commissioners with the delegates shall be held on the 29th of the coming April at 1 o'clock in the municipal hall.*

*The translation of this and the following document is by Dr. George M. McBride.

ACUERDO

aprobado por los delegados nombrados
para efectuar el cambio en el orden de los turnos
del riego del Valle.

—:O:—

"En Copiapó, a dos días del mes de Mayo de mil ochocientos setenta y siete, reunida la comisión que suscribe, nombrada por los señores delegados de los distritos regadores del valle, para formular un proyecto para el cambio del actual sistema de riego; hallándose presente el celador mayor de aguas, después de un detenido examen de las razones dadas por él, cree admisible y propone a los delegados y propietarios del valle, el siguiente proyecto:

En atención que de todos los distritos solo el primero y el tercero son los únicos que toman el agua en sus propias tomas a la hora que les pertenece sin sufrir la menor pérdida por traerla del distrito superior inmediato y teniendo además presente que todos los demás distritos tienen de esa dotación de aguas cierto número de horas nominales que son las que pierden en conducirlos del distrito anterior, opina la comisión que dando cada distrito para el lleno del río el número de horas nominales que tenga y además una parte proporcional para el avaluú que se haga de las horas de la cortada de la ciudad y que recibiendo el resto, mas la cortada del distrito superior inmediato, se colocan en la misma situación que los distritos primero y tercero.

Cada distrito debe dar para el lleno del río, lo que pierda en traer el agua a sus últimas tomas desde las últimas tomas del distrito superior inmediato, mas una parte proporcional para cubrir el número de horas en que se aprecie la cortada de la ciudad.

Estas pérdidas serán:

Para el 2.º distrito el tiempo que tarda el agua desde la toma de Goyo Diaz a la de Palo Blanco.

Para el 4.º distrito desde que llegue a la toma anterior hasta que llegue a la del Carrizo en Hornito; debiendo tenerse presente los riegos que lleguen antes que el agua de Cordillera para rebajarlos de su pérdida.]

Para el 5.º distrito lo que tarde el agua desde el Carrizo hasta el desagüe de la máquina de Totoralillo o por la toma que destoman actualmente o por el cauce del río o por ambas a la vez.

Para el 6.º distrito lo que tarde el agua desde las tomas anteriores a la denominada de Esbry, para las haciendas de Nantoco y Cerrillos para el resto del distrito hasta que llegue a la de San Roman.

Para el 7.º lo que pierda desde esta última hasta la de Melendez.

Para el 8.º desde la de Melendez al Crucero.

A la hacienda de Jorquera uno de sus riegos doce horas antes de empezar a regar el primer distrito y el otro a los siete días y a la misma hora

El riego para la hacienda de Pulido doce horas antes de recibirlo el 5.º distrito.

El riego de la hacienda de Manflas queda en las mismas condiciones que actualmente está.

2.º Establecer cuatro épocas en el año para calcular la pérdida de cada distrito; dichas épocas serán: primer turno de Enero, 1.º id. de abril, 1.º id. de Julio y 1.º id. de octubre.

3.º Todo interesado de una acequia está en la obligación de tapar su compuerta y dejarla bien asegurada para que las filtraciones de los distritos superiores bajen y refresquen el cauce del río sin ser permitido a nadie hacer de ellas el menor uso y para que al bajar el agua a la ciudad no se pierda nada por filtraciones a las tomas, bajo la pena de 10 \$ de multa.

4.º Para evitar cortadas perjudiciales, los establecimientos industriales tomarán el agua para el movimiento de sus máquinas, cuando al bajar para la ciudad llegue al distrito donde se hallen ubicadas y tendrán la obligación de hacer asegurar todas las compuertas de las acequias aurtidoras, siendo responsable de cualquier abuso que se cometa y quedando sujeto a las penas del artículo anterior.

5.º La comisión llama la atención de la Ilustre Municipalidad, a la falta de un reglamento, para el uso del agua en los establecimientos industriales del valle y del ferrocarril en sus estaciones; como así mismo a las ventajas que resultarían de la compostura del cauce del río, por encontrarse éste en tal mal estado.

6.º La comisión opina por que el cambio del riego sea por el término de un año por vía de ensayos, para poder rectificar perjuicios que pudieran resultar y que por ahora no se pueden prever.

El tercer distrito hará como hace al presente su riego sin sufrir alteración alguna en el orden de su turno.

7.º Para llevar a efecto lo dispuesto en el precedente acuerdo, se nombrará una comisión pericial por los delegados y por la comisión municipal, tratando en lo posible que ella sea formada por personas que no tengan interese directo en el riego.—*Guillermo Watkins*.—*Juan 2.º Sierralta*.

Copiapó, mayo 22 de 1877.—Es copia fiel del original que queda archivado en la secretaría municipal.—*José M. Grove*, secretario.

RESOLUTION

adopted by the delegates appointed to effect the change in the system of rotation practices in the irrigation of the valley.

In Copiapó, May 2, 1877, the undersigned Commission, named by the delegates of the irrigation districts in the valley, for the purpose of formulating a plan for a change in the present system of irrigating, having assembled (the chief water-master being present), after a careful consideration of the reasons advanced by him, has decided that the following plan will be acceptable and proposes it to the delegates and the proprietors in the valley:

In view of the fact that, of all the districts, only the first and the third receive water at their own head gates at their corresponding hours without any loss in bringing it from the next higher district; and, in view of the fact, also, that all the other districts have a certain number of hours belonging to them which are merely nominal, inasmuch as these hours are lost in bringing the water from the district that precedes them: the Commission believes that, by having each district give up, for the filling of the river, the number of nominal hours which it has, and, in addition, a proportional part for the estimated hours in which the water is devoted to the city, and, receiving the rest plus that taken from the district immediately above, they [the districts] would be placed on equal footing with the first and the third districts.

Each district should give, for the filling of the river, the time which it loses in bringing the water to its last head gates from the last head gates of the district immediately above, plus a proportional part to cover the number of hours estimated as required for the city's supply.

These losses shall be:

For the second district, the time which it takes the water to go from the head gate of Goyo Díaz to that of Palo Blanco.

For the fourth district, the time from the arrival of water at the last-named head gate to its arrival at the head gate of El Carrizo in Hornito; keeping in mind the waters that arrive before the water of the Cordillera, in order to deduct them from its loss.

For the fifth district, the time it takes the water to go from El Carrizo to the wasteway (*desagüe*) of the machine at Totoralillo, either through the gate that is at present in use for waste, or through the channel of the river, or through them both at the same time.

For the sixth district, the time it takes the water to go from the last-mentioned head gates to the head gate called Esbry, for the haciendas Nantoco and Cerrillos; for the rest of the district, until it arrives at the head gate of San Román.

For the seventh district, the time that is lost from this last head gate to that of Meléndez.

For the eighth, from that of Meléndez to [that of] the Crucero.

The hacienda of Jorquera [shall lose] one of its irrigating periods twelve hours before the first district begins to irrigate, and the other, seven days afterwards, and at the same hour.

The irrigating period twelve hours before the fifth district receives water [shall be lost] by the hacienda of Pulido.

The irrigating period for the hacienda of Manflas remains as at present.

2. The Commission proposes the establishment of four periods in the year for calculating the loss to each district: (1) the first turno of January; (2) the first turno of April; (3) the first turno of July; (4) the first turno of October.

3. Each person having interests in an irrigating canal is under the obligation of closing his canal gate and leaving it safely closed, in order that what-

ever water seeps out from the districts above may come down and moisten the channel of the river, no one being permitted to use these waters in any way; and in order that when the water comes down to the city none of it shall be lost by filtering through the canal gates; penalty for violation of this measure being a fine of 10 pesos.

4. In order to avoid injurious shut-offs, the industrial establishments shall take the water for the running of their machinery when the water, on its way to the city, reaches the districts where they are located, and they shall be obliged to see that all the canal gates of the distributing canals (*acequias*) are securely closed; being held responsible for any abuses committed and subject to the same penalties as mentioned in the foregoing article.

5. The Commission calls to the attention of the Honorable Municipality the lack of regulations governing the use of water in the industrial establishments of the valley, as also in the stations of the railway; and also to the advantages which would result from making repairs in the channel of the river, which is in such bad condition.

6. The Commission proposes that the change in the system of irrigation be for the space of one year as an experiment, in order that defects which may become apparent but which cannot be foreseen may be corrected.

The third district shall continue to irrigate in the present way, suffering no modification whatever in the order of its turno.

7. In order to put into effect the measures proposed in this resolution, a committee of experts shall be named by the delegates and the municipal Commission, as far as possible composed of persons who have no direct interests in the irrigating system. (Signed) Guillermo Watkins. Juan 2°. Sierralta.

Copiapo, May 22, 1877

This is a correct copy of the original which remains in the archives of the municipal secretary. (Signed) José M. Grove, Secretary.

of the sudden interruption in the process of stealing water from his neighbor's canal. It was pointed out to me that the Decalogue does not include water among the things that shall not be coveted, hence water diversion from a neighbor's ditch at three o'clock in the morning seems to the drought-stricken farmer to resemble theft less than intense business rivalry.

THE TURNO IN ARGENTINA

Pierre Denis has described similar conditions on the eastern side of the Cordillera in Argentina: "At Mendoza and San Juan the water-rights, codified in provincial laws which date, like the dams, from the end of the nineteenth century, are very different from the water-rights which hold in the Andean provinces of the northwest. The variety of the physical conditions is reflected in the institutions. Here water is not an object of private ownership independently of the soil. The

concession of water is assigned to a definite estate, and it is formulated in superficial measurements. The law fixes the volume of water that goes with each unit of surface. If the output of the river is not large enough to provide the volume stated in the law to the whole of the irrigated district, all the lands with definitive rights receive at least an equal amount, and the available water is shared by the canals in proportion to the extent of the surface they irrigate.

"No law could secure for the farmers of Cuyo, even those with definitive rights, a constant supply of water, or save them from suffering in common from the variation in the volume of the torrents, and it was not even possible to guarantee them water in any permanent fashion. The *turno* is used everywhere when the water is low. Lower down, where the drought lasts nearly the whole year, the *turno* is the standing rule. At La Paz, on the fringe of the irrigated area, it has to be applied rigorously. The turn of each owner comes every eight, ten, or twelve days. In normal times he receives the *suerte de agua*; that is to say, the output of a sluice of a fixed size during a half-hour for each hectare (a little over two acres) of land. But if the river runs low, it becomes impossible to supply several neighbors simultaneously, and, in order to avoid making the interval between supplies too long, the duration of the *suerte de agua* is reduced by half or three-quarters.

"The oases of Cuyo are like the small oases of the northwest as regards the function of those who are engaged in the administration of irrigation. The water-laws give the provincial functionaries general directions. Below them, however, to arrange the distribution of the water and the upkeep of the canals in detail, they have allowed to survive, and have merely regulated, certain primitive democratic organisms. At San Juan the superintendence of the irrigation is entrusted to elected municipal councils and the governor of the department. At Mendoza, the owners appoint a council of three delegates and an inspector for each canal, and these settle the annual budget of the canal, submit it to the provincial authorities, receive the taxes, carry out the necessary repairs, and so

on. The great subdivision of property and the large number of electors make these little republics very lively; and they are very jealous of their autonomy."⁵³

SIMILARITIES IN ARID AFRICA

In the simpler societies of the world where there is a close dependence upon natural conditions of soil and climate there is also great similarity of customs and means of life. Tibet and the Puna de Atacama have many resemblances. Desert folk in Atacama are in certain ways strikingly like those of the Sahara or the Kalahari desert in Africa. Like the turno of Chile and Argentina is the system of water measurement in use in Algeria. From Hilton-Simpson's extremely interesting book "*Among the Hill-Folk of Algeria*"⁵⁴ I quote the following passages:

"The system of irrigation in use at Beni Ferah is that which obtains all over the Aurés, and, as its study brought to our notice a very quaint method of measuring time, we may examine it in some detail. At a point situated some distance above the gardens the river is tapped by means of a barrage, often consisting merely of a line of boulders so placed as to deflect a certain amount of the stream into a narrow canal, known in Algeria as a 'seggia', by means of which it is conducted through, or rather beside and slightly above, the land to be cultivated, each garden possessing its own branch channel from the main 'seggia' by means of which it can be flooded in its turn. . . .

"When a garden is purchased the buyer must acquire, also by purchase, the right to a supply of water according to its size; thus an extensive property may require the uninterrupted flow of all the water in the canal which irrigates it for one whole day in the week, while another may only be allowed one or more hours of irrigation in the same period.

"The stream is tapped by more than one main 'seggia', and

⁵³ Pierre Denis: *The Argentine Republic*, New York, 1922, pp. 85-86. See also footnote 93, p. 209, for reference to water rights in northwestern Argentina.

⁵⁴ M. W. Hilton-Simpson: *Among the Hill-Folk of Algeria*, London, 1921, pp. 43-45.

the flow of water is turned into these in turn. Upon the day on which any given 'seggia' is to be used the owners of the various gardens situated beside it assemble and, repairing to a point overlooking the gardens, proceed to divide the flow of water between them.

"So precious is the liquid that even a few moments more or less in the period of its flow into a garden is of considerable importance; the Shawia therefore mistrust the employment of modern watches, whose rate can be dishonestly adjusted, as a means of measuring the time for which each owner is entitled to the flow of the canal.

"Instead, they make use of a system of measuring time which must be of very great antiquity, and has probably persisted in this land of survivals for countless generations in company with other strange customs of the Shawia.

"A member of the village council accompanies the landowners, bringing with him a large earthen bowl, or metal pail, of water, and a small copper bowl, the bottom of which is perforated with a very minute hole; at the moment when the mud wall of the 'seggia' is cut through and the water allowed to flow into the first garden the councillor carefully places the perforated bowl, the property of the village council, and therefore the legal measure, upon the water in the pail, watching carefully for it to sink, which it will do in about fifteen minutes, and refloating it again immediately it does so. Thus each landowner is entitled to three, four, six, or eight, as the case may be, sinkings of the copper bowl rather than to any given number of actual hours or portions of an hour, and as the time approaches when the flow of water into a garden is to cease, a neighbor in the little group of landowners will shout to an assistant in his garden below to be ready upon the instant to cut open an inlet into his land in the side of the 'seggia' as soon as the bowl has sunk for the last time in the series allotted to his friend, who at that moment will cry out to a man in his garden to stem the flow of water he has been receiving by filling up with mud the hole through which it has been running.

"Each landowner being present in person, and the fact that

the measuring is done by an elder with the official bowl, appears to ensure that this quaint old-fashioned method of measuring time gives satisfaction to all concerned.

"The lack of a sufficiency of water, which has called into use the water-clock just described, also tends to maintain in existence an old custom connected with prayer for rain which may well have existed in Algeria for countless ages before the arrival of the Mohammedan faith, and which, when once we had observed it, helped us considerably towards commencing our investigations into the superstitions of the Shawía."

A YEAR OF RAIN

But there is a happier aspect to the picture of the struggle for water. With what enthusiasm a desert dweller still speaks of the years of abundance—when the rains come, and there is plenty for all. The influence of the seasons on the valley people is as marked as ever. In spite of a railroad, a higher degree of organization, and a position near one of the routes of world commerce, the Copiapeños find the rains of deepest concern. When showers come cattle are driven to the free upland pastures. Between 1890 and 1892 the valley stock was sent into the hills, the owners lived in tents like true nomads and in the plenty of those years forgot long-standing quarrels over water rights. The earth is then no longer a desert waste. Where sand and tough shrubs ordinarily hold sway there is now wild clover, knee-deep, luxuriant. The erstwhile niggardly earth yields an abundance of food, as if suddenly awakened to generosity of its own free will—*sponte sua*, as Horace observed in an environment that bred the phrase. Flowers bedeck the light-green upland meadows. It is a year of rain!

Now that the nitrate fields are in a high state of development and in chronic need of laborers, the dry years in the southern valleys are times of migration to the northern desert. There the workers remain until they hear from relatives and friends that rains have brought plenty, whereupon they drift back to old occupations—the transport of merchandise by pack train, the cattle business, the production of alfalfa, or a host of minor

projects which general prosperity encourages, if it does not create, and which general distress forces people to abandon.

THE TRANSITION ZONE SOUTH OF COPIAPÓ

The change from arid to semiarid climate at the southern end of the Desert of Atacama takes place in a very narrow belt of country about Vallenar. In the Vallenar district there is a distinct rainy season that extends from May to August. June and July have commonly the greatest rainfall: three heavy showers and it is called a very wet year. But the fact that rain may be depended upon to come *practically every year* gives a stability to ranching and valley farming which is not enjoyed at Copiapó and places farther north. At the time I visited it, in mid-July, 1913, there had been no rain whatever, and it was said that this was the first year in twelve that the drought had been so prolonged and the third year in succession that no substantial amount of rain had fallen. Yet this is only a day's journey from Copiapó where rains are not dependable at all and where instead of one dry year in twelve there is more commonly but one "wet" year in twelve (cf. Fig. 14).

The heaviest rains in the wet years at Vallenar produce damage as great as at Copiapó. When all the mountain ravines have running water the main stream, the Huasco, rises to a great height and gnaws away the lower terraces and the edges of the flood plain. In 1906 and 1907 there was high water, and in one period so much damage was done to the valley lands that the land had actually to be resurveyed and reapportioned.

Unlike the narrow and small irrigated tracts about Copiapó, the Huasco valley at Vallenar is covered with green. The whole floor is populated for fifty or sixty miles upstream, and many of the terraces are irrigated and covered with green alfalfa fields. In the midst of them stand the ranch houses, spacious and prosperous-looking in contrast to the small huts of the smaller farms on the valley floor. Above and below the city are "shut-ins," or narrow places in the valley, so that the town appears to be in the bottom of a vast bowl and, when seen from above with its great expanse of alfalfa meadows

roundabout it, presents one of the most attractive sights in the whole country (Fig. 33). The higher terraces are stony, and when the land is improved the stones are left upon the ground to prevent excessive washing. The alfalfa seed is sown and the land irrigated, stones and all, after plowing. Irrigation is said to have its best effect when the alfalfa is closely cropped, and horses and finally sheep are pastured upon the meadows to accomplish this end. The stones are then cleared away and made into stone or stone-and-earth fences. Each crop requires three soakings by irrigation, and a field once well seeded will last from fifteen to twenty years without resowing.

I visited a large ranch owned by Sir John Murray and R. W. Cummings. The manager, Mr. H. F. Wakefield, showed me about the ranch, which is called Hacienda de la Compañía Agrícola. It is fifty miles long and twenty-five miles broad in its widest part, narrowing to five miles. It is devoted exclusively to the growing of alfalfa and the fattening of live stock. The baled alfalfa is exported to the nitrate establishments of the desert farther north and in 1913 sold for 6 pesos per bale of 150 pounds. There are three crops of alfalfa a year, and the total production of the ranch is 50,000 bales. This is the maximum production in a good season, and there were then 350 cuadras under cultivation. The main canal which feeds the ranch is 21 kilometers long and cost 400,000 pesos Chilenos to build. (The canal feeding a large ranch on the opposite side of the valley cost 700,000 pesos.) It is two meters broad at the intake and when full will carry water 40 centimeters deep. Water rights were obtained from the government in 1903, and the ranch is permitted to irrigate three days a week to the full capacity of the canal.

Part of the business of the ranch is the raising of cattle. These are imported from the Argentine or brought from farther south in Chile. The cost of pasturing the cattle on the ranch runs from 12 to 16 pesos per month per head. When the stock is fattened the owners then ship it to the nitrate oficinas or to the markets of the coast ports.

The people who live in Chile at the edge of the desert are necessarily on the lookout for fresh material advantages.



FIG. 36



FIG. 37

FIG. 36—Hauling alfalfa in oxcarts to the railroad station at Vallenar for shipment to the nitrate pampa. Estate of Sir John Murray.

FIG. 37—Administration building and residence of the manager of Hacienda de la Compañía Agrícola, Vallenar, Chile.

There are three specialized industries in this part of South America that deserve particular mention: the trade in firewood, the gathering of algarrobilla, and chinchilla hunting.

A LOCAL TRADE IN FIREWOOD

All of the principal valleys about Copiapó and Vallenar have been settled for a long time, in fact since the Conquest; and the natural, or wild, growth of wood has been gathered up and down the valley and for some distance out into the desert, just as about the mines and settlements of Bolivia and Peru llareta (moss) and tola bushes are gathered at greater and greater distances with the increase of population and the rise of modern industry.

In Copiapó and Vallenar the mines have brought increasing populations, and the point has been reached where the valleys do not supply all the necessities. A growing quantity of foodstuffs and other essentials are being imported, and among them is wood. It is said that Vallenar was built originally of wood cut in the lower Huasco valley and that Copiapó once stood in the midst of a rather dense stand of wood, taking in 1744 the name San Francisco de la Selva. The rapid cutting and burning of the natural growth took place about one hundred years ago. It is traditional that the province of Atacama had a widely extended woodland dependent in some places upon ground water, once standing at a higher level than today, in other places upon the coastal fog and more frequent though scanty showers that fall in the coastal belt, as about the bay of Coquimbo and southward.⁵⁵ The present commercial supply of wood at Copiapó comes from a wild growth of shrubs forty miles south of Vallenar in the Huasco valley. With the opening of the railway in the past decade it became possible to gather and market wild stands that were formerly considered commercially inaccessible. The best stands of wood are found in that portion of the Huasco valley which is naturally sub-irrigated and yet which does not tempt agriculture. Thirty

⁵⁵ Walter Knoche: Über die nördliche Waldgrenze in Chile, *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1923, pp. 41-45.

or forty miles up and down the Huasco valley extend the flatter lands where the valley farmers live, and there a company has developed a vast ranch that uses the principal part of the water supply. Outside its holdings any one can cut the wood and sell it to the dealers. The wood consists of crooked roots and stumps of gnarled desert shrubs six to eight feet high and is sold even in the smallest quantities. Children come to the dealer's counter to obtain from two to five cents' worth of wood at a time or barely enough to cook a single meal. Wholesale it costs from eight to ten pesos per one hundred kilos, or one dollar per hundred pounds.

Wood that is obtained from the highest elevations at which it is gathered is called *leña barrilla* and is brought down to the railway by burros. A man will leave the valley and travel three days out across the desert foothills to reach the ravines and favored spots where the shrubs grow. He will spend one day cutting them and three days coming back. The best wood in the cordillera is the resinous and green tola bush. It has bright yellow flowers in season and a strong odor, which it imparts to food cooked over the fire. A plant closely resembling the tola is called *tolilla*, but it has a very limited distribution. *Pata-del-oro* is like a small conifer and gives out a strong odor on burning, which is also imparted to the food cooked over it. It grows much taller than tola, is very resinous, and is not found in localities where other woods grow. It is confined to situations of modern elevation.

In some localities the people are supported principally by traffic in wood, as in the foothill belt where wood is gathered in the moister ravines and taken to San Pedro and other towns of importance, the beasts that carry it being loaded with provisions on the return journey. On the eastern side of the cordillera there is an extensive commerce in *cardón*, also called *quisco*, the straight cactus (*Cereus atacamensis*).

GATHERING OF ALGARROBILLA

About Vallenar and eastward to the mountains there grows a shrub called *algarrobilla*. It is from two to five feet in height

and looks somewhat like one of the smaller mimosas. It produces a pod about the shape and size of a peanut. The matured pod makes a black ink upon infusion with a mordant; but is mainly used by tanners, as it greatly accelerates the process of tanning. It is also used in the cleaning of boilers. It began to be exploited commercially about 1890. It is now gathered by the natives and sacked for storage. When a sufficient amount has been gathered for a shipment it is taken to port, chiefly to Vallenar, and sent to the tanneries of Europe, principally to Liverpool (and to Hamburg before the World War) except for 3000 to 4000 bags which are used by the tanneries of Chile. In rainy years—that is after two or three showers in winter—there is a crop of 20,000 or 30,000 bags of 200 pounds each which averages in Liverpool about £14 per ton. In 1913 the crop amounted to 20,000 bags, and at the prices then prevailing was worth \$100,000. In rainless years the bush does not produce fruit. It is uncultivated and is decreasing, owing to the fact that it is cut for fuel. It grows only to the north of La Serena and the south of Copiapó.

In years of favorable rains donkeys and mules bring down wood, algarrobilla, and the products of the smallest mines scattered through the mountains. In bad years the mules must be fed on stored alfalfa; this makes it expensive to use them in transportation away from the irrigated valley, with the consequence that the ores of the scattered mines are allowed to accumulate, and the supply of algarrobilla falls off. In such times the gatherers of this plant become greedy of rivals and take the product green, letting it ripen in the house or courtyard. It is then inferior to the naturally ripened product. "Cueva" algarrobilla is that stored in holes in the ground by rodents. The natives gather it to supplement poor crops, but it is in such condition as to command only a low price.

CHINCHILLA HUNTING

The tiny chinchilla has a silver gray and extremely fine and light fur, one of the most highly prized of commerce. The animal inhabits crevices in the rock and openings in loose piles

of stone in the high cordillera and, so far as I know, does not now live at low elevations. The range of the chinchilla is from the southern end of the Desert of Atacama near Illapel northward through Chile to southern Peru and the highlands and mountains of western Bolivia. The chinchilla are found in greatest numbers where algarrobilla grows, but they appear to thrive in any arid, shrubby, cactus-covered country at high

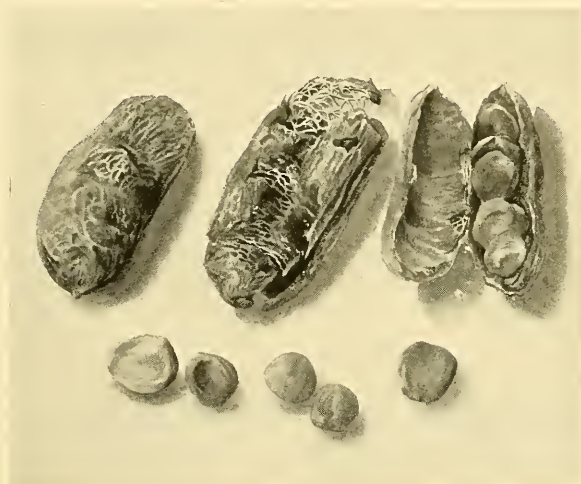


FIG. 38—The pod and seeds of the algarrobilla in natural size.

elevations where natural rock piles accumulate and furnish a cavelike shelter difficult of access. They live on grains, seeds, wild onions, herbs, lichens, and algarrobilla. They seem to prefer the sweet seed of the algarrobilla, pods of this plant being found in their holes.⁵⁶ Near San Pedro de Atacama on the steep walls of a ravine formed of reddish brown sandstone we found carved the design of a chinchilla skin done to scale and faithful even to the minutest detail (Fig. 84). Closely resembling the chinchilla in size and form is the vizcacha, but its fur is coarser and longer and varies from a pleasing gray to a dirty brown. Though many attempts have been made to interest manufacturers and the public in the vizcacha fur, they have all been unsuccessful.

⁵⁶ Federico Albert: *La Chinchilla*, Santiago de Chile, 1901, pp. 8 and 10.

As the demand for chinchilla has increased, the price of the fur has increased correspondingly, and hunters have scoured every part of the Cordillera in search of the valuable pelt. The chinchilla hunters come from the little villages strung along the western edge of the mountains where the coastal desert begins, and they describe their journeys in the picturesque phrase "chinchillando en la cordillera." Ferrets, cage traps, and smoke are the means employed to drive the animals from their holes. The pelts are brought to the local markets, San Pedro de Atacama being one of the most important. When sorted and wrapped in bundles they are ready for shipment to the coast ports and thence to the northern markets.

In view of the dwindling supply of chinchilla an attempt has been made to grow them in captivity. Two companies in the United States have become interested in the plan, though with what ultimate success can only be conjectured on account of the difficulty of climate and food, but principally of climate. Certainly it is a more difficult business than fox farming.

The most ambitious effort to grow chinchilla in captivity has been undertaken on the ranch of Sir John Murray at Vallenar. There was established a chinchilla farm, probably the largest in the world. Five hundred chinchilla were purchased at the beginning of the experiment, and in a few years a round-up disclosed a population of about two thousand. The farm was enclosed by 3000 meters of wire fence, counting all the divisions, and covered an area of 25 cuadras. Covered squares of stone were provided to the number of two hundred and fifty (Fig. 39). These were covered with cane and mud; and it is better to provide this shelter than the simple rock piles, for the young can then be seen and the dead ones recovered and buried. The animals were fed chiefly upon alfalfa and a local cactus called *tunilla*, which flowers and fruits every year. Two loads of alfalfa of 46 kilos each were fed weekly to the chinchilla, and 16 *arrobas* of *tunilla* of 25 pounds each. The farm declined with an invasion of rats, and from present reports the experiment seems to have been abandoned.

In 1911 a party of about fifteen chinchilla hunters came up from Coquimbo and Vallenar and hunted the whole cordillera



FIG. 39



FIG. 40

FIG. 39—Artificial mounds in which the chinchilla live on the farm of Sir John Murray, Vallenar.

FIG. 40—A part of Sir John Murray's chinchilla farm, Vallenar. The wire fencing is sunk in a trench.

as far north as San Pedro and even beyond, penetrating most of the valleys of the Cordillera Domeyko (Fig. 87). They brought with them small and thin dogs that could enter the chinchilla holes, and so thoroughly did they clear out the chinchilla that they have been scarce ever since. I paid 30 pesos Chilean, or \$6 in U. S. money, in San Pedro for a good chinchilla skin in July, 1913. (It is worth \$25 gold in the United States.) In Albert's account of the chinchilla quoted above there are given statistics of the export of chinchilla skins from Chile and the measures best calculated to conserve the industry. He estimated that out of the departments of Vallenar and Coquimbo half a million skins were shipped annually (1900) and that the extinction of the animal would follow unless conservation measures were enforced.

CHAPTER VII

EARTHQUAKES AT COPIAPÓ AND THE ROARING MOUNTAIN OF TOLEDO

One of the few two-story houses in Copiapó is the Hotel de Atacama, kept at the time of my visit by Bosman, a Dutchman from South Africa. The beds occupy the inner corners of the sleeping rooms where experience has shown there is the greatest safety at times of earthquake, owing to the stability given by converging walls. From side to side under the ceiling of my room there ran a heavy iron rod which pierced the walls and held in place great round iron clamps visible on the outside. The rod tends to prevent the outer wall from being thrown out in times of earthquake, thus allowing the roof to crash down. The cracks in the walls and the ruins of many old earthen houses in the suburbs attest the violence of past earthquakes for which the region is famous.⁵⁷

What was probably the most disastrous shock ever experienced by the city, occurred in April, 1819, and presented the very unusual feature of a grouping of three successive shocks, on the 3rd, 5th, and 11th, each one heavier than the preceding. The houses and churches, which were then built almost entirely of rubble masonry, were leveled, and the town was practically destroyed. When rebuilt on the same site, all the better structures were erected with wood frames filled in with adobe, and no subsequent earthquake has caused equal damage. At the time there was talk of moving the site of the city. Three years later, after another violent quake, many people went from Copiapó to Huasco to live.

The records of the Copiapó Mining Company (see following chapter) contain an account of an earthquake which occurred at 8 A. M. on October 5, 1859, and did much damage through-

⁵⁷ Details of the seismological history of southern Peru and northern Chile are given in F. Montessus de Ballore: *Historia sísmica de los Andes Meridionales*, Part II, Santiago, 1912. See also C. M. Sayago: *Historia de Copiapó*, Copiapó, 1874.

out the province, and there follows the accompanying table of damages:

Houses completely ruined.	115
Houses uninhabitable.	224
The re-erection of which will cost.	660,000 pesos
Losses in <i>tapias</i> (mud walls), garden walls, and enclosures.	140,000
Shopkeepers' losses in goods and furniture.	40,000
Public buildings, repairs to church, prison, hospital.	80,000
Other losses.	10,000
Total.	930,000 pesos

It is further noted that all the smelting works at Caldera were totally destroyed except those of the Copiapó Smelting Company, whose establishment was built on rocky ground.

After the earthquake of 1877 many of the townsfolk slept in the hills every night. In June, 1909, there was also a severe earthquake. Considerable damage was done in the earthquakes of 1918 and 1922. Under such circumstances the people run out into the streets at even the slightest shocks. I witnessed such a scramble from indoors in July, 1913, when a slight shock was felt. I had earlier had a similar experience at Pica east of the nitrate desert. In the latter case the distant but rapidly nearing rumble that preceded the sharp shock was most impressive.

EFFECTS OF THE EARTHQUAKE OF 1918

Only a few of the better class of houses in Copiapó are made of wood, and even these have outbuildings or extensions made of other material, such as adobe and cane. Some of the wood for house building is imported from southern Chile; and some, the greater part, is imported from Oregon, Washington, and California. By far the larger part of the city is composed of houses of a cheaper class. There are four main types of houses: (1) cane of Guayaquil, (2) brea (a resinous shrub), (3) adobe, and (4) earth, according to the classification of Linnemann.⁵⁸ The types are named in the order of their quality, from the best down. The houses made of earth are built of blocks about

⁵⁸ Clemens Linnemann: Informe sobre el terremoto de Copiapó del 4 de Diciembre de 1918, *Bol. Minero. de la Soc. Nacl. de Minería*, Vol. 34, 1922, pp. 412-420.

half a meter wide and one and a half meters long. The earth is obtained from the flood plain of the Copiapó River and is molded in the form of rough blocks. These are laid one on top of the other to the height of the walls, which is about six feet. In almost all cases houses of this type are made without a framework of wood or any other kind of protection. Upon the tops of the walls firmer material made of adobe must be placed in order to bear the weight of the roof. The walls are then plastered over with a layer of mud to make an even surface. The roof is in most cases flat or nearly so and is composed of a framework of wood covered with cane or reed, and this in turn is covered with mud. Every year or two a fresh layer of mud is plastered over the old layer, a thick and heavy mass being built up in this way. Houses of this type can be constructed at little cost.

More expensive is the adobe type of house, also made of thin blocks of earth molded and dried but supported in critical places by wooden uprights and of crude construction which give a wall of greater flexibility. The outer surface of the wall is plastered over as in the former case. The brea type is made of bundles of this shrub fastened against wooden uprights, and the outside is covered with a layer of mud as in the preceding types. The mud adheres to the brea, and the whole wall has greater flexibility than in the previous cases. In the fourth type of house vertical uprights are put in place; against the outside is attached a layer of cane, and the whole covered with mud. This type of wall has still greater flexibility, but it is necessary to import the cane from Ecuador and its high cost prohibits its use among all but the well-to-do.

Linnemann studied the earthquake of December 4, 1918, with special reference to the damage done to different types of structures. The houses are sixty or eighty years old for the most part, and the greater number are rented. Practically no house was free from damage of some kind. But of a total of 1630 houses in Copiapó, 344, or nearly 21 per cent, were totally destroyed. Of seriously injured there were 349; and the rest, or 944, that is to say 57.8 per cent, suffered injuries of little importance.

The four classes of houses constitute percentages of the total as follows: cane, 27.2; brea, 24.7; adobe, 21.3; earth, 26.8. There being little resistance between the blocks of earth of the last type and no restraining uprights of wood, they move over each other easily in times of earthquake; and the heavy roofs, commonly in a state of disrepair, readily fall down. Linnemann has given an interesting table and some figures for the damage done to the four types in the quake of 1918, and I quote them in Table II.

TABLE II—EARTHQUAKE EFFECTS ON VARIOUS TYPES OF HOUSES

	CANE HOUSES		BREA HOUSES		ADOBE HOUSES		EARTHEN HOUSES	
	NUM- BER	PER- CENT- AGE	NUM- BER	PER- CENT- AGE	NUM- BER	PER- CENT- AGE	NUM- BER	PER- CENT- AGE
Totally destroyed. . .	4	0.9	54	8.4	57	16.3	249	56.6
Seriously damaged. . .	25	5.6	81	20.0	106	30.4	138	31.4
Slightly damaged. . .	417	93.5	290	71.6	188	53.3	53	12.0
	446		405		349		440	

Nothing could better illustrate the practical effects of earthquake studies than the analysis which Linnemann has made, for it shows how greatly the death rate can be cut down by insisting upon construction of the best sort. It would be wise policy for the government to prohibit the making of the cheapest class of house, for the capital value of a family is far greater to a country than the difference in cost between constructing a house made of earth or adobe on the one hand and one made of cane on the other.

THE EARTHQUAKE OF 1922

On November 11, 1922, one of the most severe earthquakes in the history of Chile was experienced. Professor Bailey Willis, who has studied this earthquake for the Carnegie Institution, emphasizes the danger of the heavy and rigid earth-and-adobe structures commonly used in Copiapó and Vallenar.

"To construct a house that will withstand an earthquake is

not difficult if you can command the right materials and good carpenters, but during three hundred years it has proved to be more than the unskilled artisans of Chile could do, handicapped, as they have been by poor wood, wretched mortar, and the evil inheritance of adobe buildings. They used to put together structures that were pinned with wooden pins and tied with rawhide, which were both strong and elastic. Some of them have passed through the earthquakes of the past century without serious damage. The introduction of iron nails, which are so easily driven, appear to hold so well, but in fact pull out with ease, has resulted in much weaker frames, that are quite unequal to the task of upholding the heavy walls and roofs of adobe. Back to the good old joinery should be the cry. Rawhide should be used if convenience and cheapness require, but galvanized fence wire is better when skillfully stretched or tied. And adobe should be used only to fill thin walls, never in heavy masses. . . .

"There is one thing about building to resist earthquakes that people seem to forget: an earthquake can exert no more force to wreck a building than is necessary to overcome the inertia of the structure, or of some part of it. A heavy mud-roof, such as is heaped on Chilean houses, will wrack and ruin the walls, where one of light shingles would sway with them."⁵⁹

Regarding the earthquake of 1922 Professor Willis in a personal communication to the author says further:

"It was felt from Valparaiso to Iquique, a distance of a thousand miles, disturbed the coastal region and also valleys at altitudes of 12,000 to 14,000 feet in the Andes, and shook the volcanic island of San Felix 500 miles west of the coast. It was not a very intense shock, but because of the wretched construction of adobe buildings it killed some 880 people of whom 600 were in the town of Vallenar and 200 in Copiapó. Both of these cities are built on loose ground and the unstable foundations had much to do with the destruction.

"This earthquake was accompanied by an earthquake wave which was noticed all along the coast from Valparaiso to Anto-

⁵⁹ Earthquake-proof Houses, *Science*, No. 1499, Vol. 58, 1923, September 21, pp. x-xii; reference on p. xii.

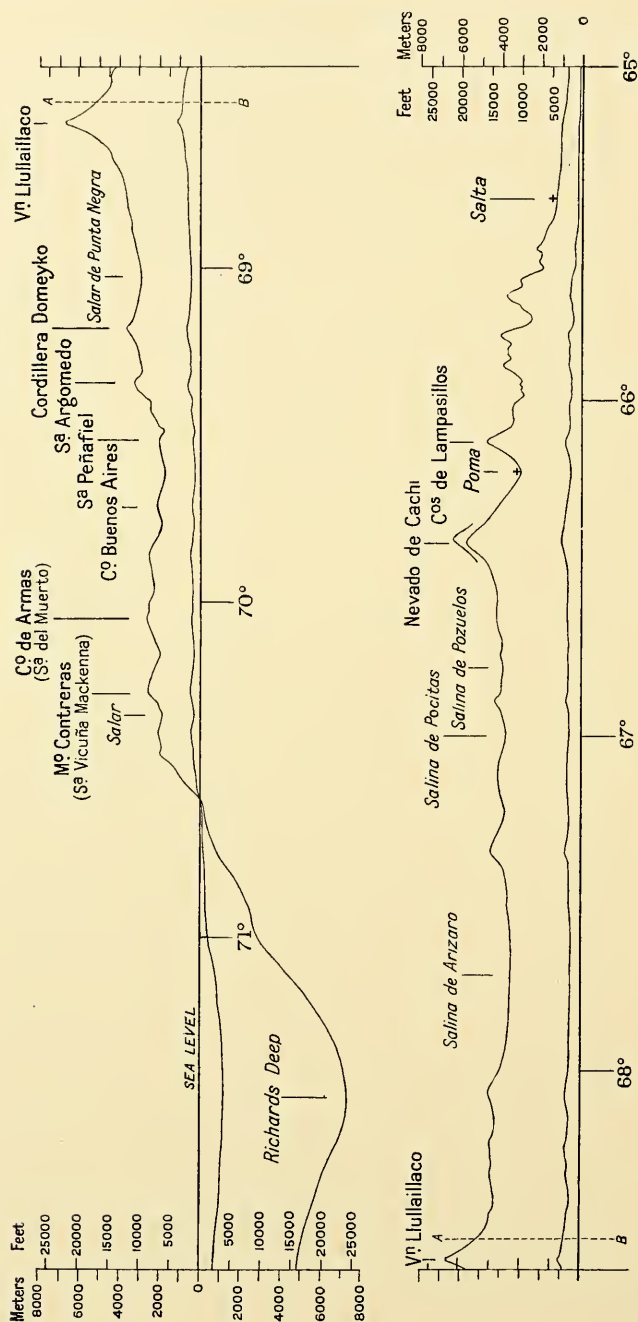


FIG. 41.—Topographic cross section of the Desert and Puna of Atacama and the entire Andean Cordillera along the parallel of $24^{\circ} 43' S.$ and between the Richards Deep and the basin of Salta. The lower profile is drawn with vertical and horizontal scales the same; the upper profile shows the vertical element exaggerated 5 times. The section is in two parts, the two lines A B being coincident. See also Figs. 2, 44, and 94. Drawn from data assembled on the Atacama sheet of the American Geographical Society's Millionth Map of Hispanic America.

fagasta and was largest in the bays from Coquimbo to Chañaral. It presented the usual character of these waves in that the sea first withdrew from the land, sinking away like an ebbing tide to a depth of many feet. The sea bottom was thus laid bare to a distance from the shore which varied with its slope. The sea then returned with three great waves which rose highest at the ends of the funnel-shaped bays. At Coquimbo the first great wave reached an altitude of 8 meters and overturned railway locomotives. Across the bay, however, at La Serena, the height of the wave was about a meter and a half only. Since many of the ports along this part of the coast are located on low ground and at the ends of the bays, the damage done by the earthquake wave was considerable, but the destructive effect was nevertheless local."

THE WEST COAST OF SOUTH AMERICA A ZONE OF FRACTURE AND DISPLACEMENT

The first law of earthquake distribution is that intensity and frequency of shock are in general greatest where the slope of the ground is greatest, that is where ocean deeps lie close to lofty mountains. There is no place in the world where this contrast is so great in a given horizontal distance as off the northern coast of Chile. The cross section, Figure 41, represents the astonishingly abrupt transition from lofty table-land to abyssal ocean depth that is characteristic of the entire coast. It represents conditions along the coast of northern Chile in the vicinity of Taltal, where the Andes, attaining a height of over 16,000 to 18,000 feet (Mt. Llullaillaco, Figure 93, is over 20,000 feet high), fall off to the enormous depth below sea level of over 25,000 feet, a total descent of more than 40,000 feet in 175 miles, most of which (32,600 feet) is accomplished in 75 miles. From the northwestern coast of Peru southward to Concepción, in southern Chile, the 4000-meter submarine contour is never more than 125 miles from the coast and generally less than half that distance away. We have here one of the great planes along which a major segment of the earth's crust is undergoing adjustment; the line of movement being often-

times indicated by earthquakes, and the amount by geologically "recent" shore forms of unmistakable identity only moderately eroded since their uplift.

As we sailed southward from Coloso, with the land in view, there could be seen everywhere along the coast signs of recent uplift. By this I do not mean necessarily uplift in the human period but in recent geological times, and the shells and marine débris that one finds on some of the raised beaches are exactly like those that one may pick up on the active beaches today. At the mouth of the Copiapó valley is a terrace that stands about 150 feet above sea level and stretches up and down the coast, appearing to correspond to the 150-foot terrace at Antofagasta and Coloso. Going up the Copiapó valley one can trace the terrace far inland. Six kilometers from Caldera at the station called Carpa No. 1, at an elevation of over 400 feet, is a terrace whose surface is literally a solid mass of marine shells deposited in hollows of a rock-cut surface—evidence that the sea floor and the land are here parting company along the edge of the continent and that the uplift of the land may be called a continuing process. The actual movement of the crust at the moment may not be upward; the coast may be stationary or it may even be sinking, but the *trend* of the coastal movement is distinctly upward and has been upward in the later stages of geological history.

At the port of Paita in northwestern Peru one may obtain a very clear notion of the recency of the crustal movements that have affected the land thereabout. On the left of Figure 43 a cut terrace only a few feet above sea level may be observed. It runs up each of the reëntnants and rounds all the spurs with even contour. Its materials are of exactly the same sort as those in the existing beach below it, and the shells occurring in it are likewise identically like those on the present shore. It appears to have been formed but yesterday, so fresh are its details of structure and relief. Just outside the port, at the Punta de Foca, are wider terraces cut into the rock as well as the soft sands and gravels that overlie the rock. It is now being scored by the intermittent streams dependent on the so-called "seven-year rains" and is being cut off on the seaward



FIG. 42



FIG. 43

FIG. 42—Coastal terraces at Mollendo, Peru. They extend from the foot of the Coast Range to the shore, a distance of several miles.

FIG. 43—Coastal terrace at Paita, Peru. It is cut in part in solid rock

side by wave action. Its smooth upper surface in the inter-stream areas is still strewn with wave-rolled material; and the beach, except for the work of the scoring streams, seems as in the previous case to have been exposed but yesterday.

The most extraordinary development of wave-cut terraces, now uplifted, which I have observed on the west coast of South America is that at the port of Mollendo, in southern Peru (Fig. 42). The terraces increase in height from the northern part of the Peruvian coast and reach a splendid development at this point. They are visible at sea as long, gently-sloping, rock benches of huge size. Opportunity was afforded for the more detailed examination of their upper surfaces than was possible in the preceding cases (Paita, Lomas, Pisco, Eten, etc.), and it was found that evidence for their formation by the sea and subsequent uplift to a height of at least 1500 feet is conclusive. About the inner margin of the terraces are coves like those now seen at many places on the present strand line or but a little above it. They are not so clearly distinguishable as the latter because of the partial filling or obliteration they have suffered, but their characteristic outlines are still to be made out with certainty. The whole aspect of the terraces with their regular outlines is in striking contrast to the comparatively irregular forms of the mountain side above them where there has been no planing action by the sea.

It would be a repetition of the foregoing descriptions to note the individual features of the different terraces observed along the coast farther south; and, as these have been described to some extent in the accompanying list of papers,⁶⁰ their description here is unnecessary. At Iquique, Tocopilla, Antofagasta, and elsewhere, they are developed as clearly as in the

⁶⁰ The literature of the subject is still very limited. The following are a few of the more important references:

F. V. Gormaz: Depressions and Elevations of the Southern Archipelagoes of Chile, *Scottish Geogr. Mag.*, Vol. 18, 1902, pp. 14-24.

Otto Nordenskjöld: Über einige Erzlagerstätten der Atacamawüste, *Bull. Geol. Inst. Univ. of Upsala*, Vol. 3, 1898, pp. 343-351.

O. H. Evans: Notes on the Raised Beaches of Taltal (Northern Chile), *Quart. Journ. Geol. Soc.*, Vol. 63, 1907, pp. 64-68.

Charles Darwin: Journal of Researches into the Natural History and Geology of the Countries Visited during the Voyage of H. M. S. Beagle round the world, 2nd edit., London, 1860.

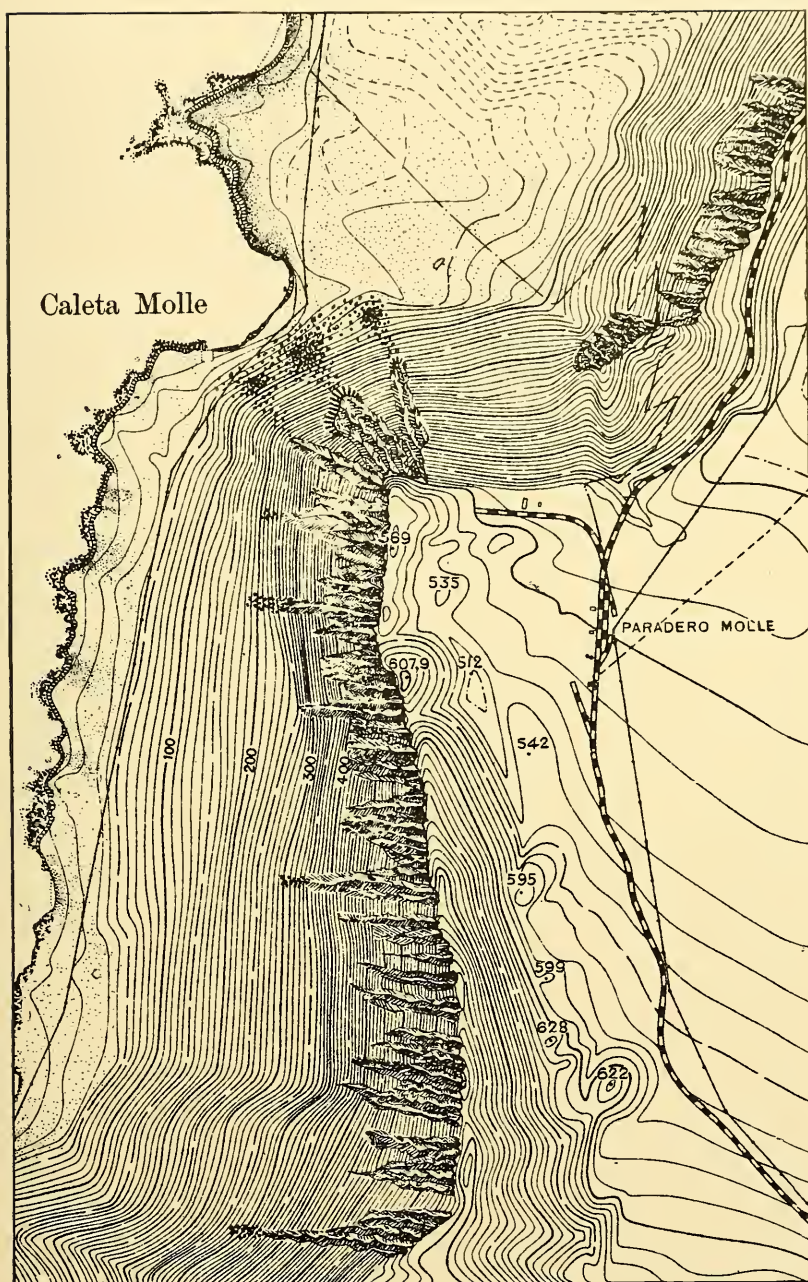


FIG. 44—Steep and in places precipitous border of the continent, a crumbling coastal wall that registers the break between the land and the sea floor. Caleta Molle is in latitude $20^{\circ} 13' S$. The scale is approximately two inches to the mile. Photographed from the map of the Iquique region, Oficina de Mensura de Tierras.

situations already described. In each case the topographic outlines are as clear an index of their manner of formation as are the shells found upon the terraces at Paita, Camaná, and Caldera. Though these embedded and contemporary shells are interesting confirmatory evidence, they are not really essential to the proof of formation by the sea and geologically recent uplift, for the topographic evidence is of a thoroughly conclusive sort.

If the boldness of the desert coast is a measure of Andean scenery the traveler may well feel that what lies "behind the ranges" is worth crossing the desert to see. It is therefore no less than astounding to climb the steep and in places precipitous coastal scarp (Fig. 44) and find oneself among tame and rounded hills that form the summit and eastern border of the Coast Range (Fig. 94, p. 267). It is only the coastal scarp that is physiographically young; the Coast Range has every mark of great antiquity. It is not a bold mountain range but the wreck of one. It is one of the "old lands" of South America. After erosion had reduced it to its present smoothly molded aspect there came a time of profound crustal disturbance. The floor of the Pacific broke away from the edge of the continent and sank to abyssal depths. At the same time the land rose. Yet so recently in geological time have these great events taken place that the old erosion surfaces formed when the land was thousands of feet lower may still be seen not merely on the summit of the Coast Range but in the high cordillera itself. It is by such differences of form and scenery that the physiographer is able to continue the calendar of the years where the record of geological deposits is altogether missing.

The older rocks and forms show that the sea was once over what is now land and that the whole shape and contour of the continent were wholly different from what they are today. Great masses of granite were then intruded into the coastal belt, bowing it up to form a range which was subsequently eroded to its very roots. Were we able to see a picture of the coast of that time it would show a shore line probably not unlike that of the Guianas today. That the old forms of the Coast Range are still visible and but little modified from their orig-

inal condition is due to the recency of the break at the border of the continent. In addition to broad regional uplift with marginal breaking away on both the eastern and western borders, the continent was warped or bowed upward in what is now the cordilleran region.

THE ROARING MOUNTAIN OF TOLEDO

While inquiring about earthquakes I learned of their interesting effects upon a famous mountain near the village of Toledo, called El Bramador, or "The Roarer." It is a pointed volcanic mountain, some 2000 feet in elevation, standing on the edge of the Copiapó valley about 10 miles west of the city of Copiapó. It is on the estate of Señor Garay, who invited me to stay at his ranch. The mountain has the reputation in that vicinity of having been actually visited by Darwin, though as a matter of fact Darwin merely mentions the mountain as follows:

" . . . Whilst staying in the town I heard an account from several of the inhabitants, of a hill in the neighbourhood which they called 'El Bramador,'—the roarer or bellower. I did not at the time pay sufficient attention to the account; but, as far as I understood, the hill was covered by sand, and the noise was produced only when people, by ascending it, put the sand in motion. The same circumstances are described in detail on the authority of Seetzen and Ehrenberg, as the cause of the sounds which have been heard by many travellers on Mount Sinai near the Red Sea. One person with whom I conversed, had himself heard the noise; he described it as very surprising; and he distinctly stated that, although he could not understand how it was caused, yet it was necessary to set the sand rolling down the acclivity. A horse walking over dry and coarse sand, causes a peculiar chirping noise from the friction of the particles; a circumstance which I several times noticed on the coast of Brazil."⁶¹

Señor Garay's ranch is perhaps a thousand feet above sea level and is located on the south side of the valley on the low

⁶¹ Darwin, *op. cit.*, p. 361.

terrace that fringes the flood plain of the river. It is a most prosperous-looking place, with its wide-spreading gardens and alfalfa fields, the ranch house being a low, spreading affair with an enormous pepper tree over 40 feet in circumference, at the corner of the yard. Señor Garay has built three small dams on his hacienda, and these irrigate a little more than 1000 cuadras.



FIG. 45—The ranch house with its huge pepper tree whose trunk is over 40 feet in circumference at Toledo, Chile. Hacienda of Señor Garay.

There is the usual difficulty about water rights. Here, as in Vallenar, the water feuds are all the more bitter because acquaintanceship is so intimate, the size of the families so great, and the relationships of the principal families so complicated by intermarriage. Two or three families are related to nearly all the other important families in town or in the valley.

The disposition of the cultivated land in the haciendas that line the river about Toledo illustrates the manner in which the land is used, and this is pictured in Figure 46. In the middle distance is the channel of the river, which is filled with water only at rare intervals of flood. At all other times the river flows in low-water channels, or surface flow ceases altogether. Then the bed of the stream appears a broad, white, gravel-covered region, extending down valley and lost to sight behind the next

large spur. On the banks of the low-water channel and for a short distance back of the bank there is generally a wild, shrubby vegetation with coarse grasses and the like, such as grow in a zone of coarse material where there is little water supply. Still farther back from the dry river bed are the gardens and ranch houses, surrounded by tall, wide-spreading



FIG. 46—A cross section of the Copiapó valley looking down from El Bramador, the Roaring Mountain of Toledo.

trees and courtyards, made of tramped earth or, in some cases, of brick or paved with flagstones. Back of the owner's house are the cottages of the laborers, and there may be groups of these still farther up and down the valley, with paths and sometimes paved streets running between the outlying groups and the owner's house. Then come the irrigated belts, devoted principally to alfalfa but growing some corn and vegetables. The outermost zone of high terraces and foothills is given to patchy cultivation or to grazing. The higher slopes of the upland are without important vegetation except a natural growth of drought-resisting grasses and shrubs or the light green cover of grass that springs up after rain if it falls in several showers.

In the most hospitable manner Señor Garay had prepared not the simple dinner to which he had invited me at Cópíapó but a feast, and it was served with such charming simplicity and taste that it has a high place in my abundant recollections of Hispanic-American hospitality. Everything on the table, he explained to me, was grown upon the estate and reflected the



FIG. 47—El Bramador, the Roaring Mountain of Toledo, in the Cópíapó valley below Cópíapó. The large sand dune shown in Fig. 48 is here seen just to the left of the summit of the mountain.

abundance and prosperity visible on every hand when we rode out over his fields. The *pièce de résistance* was a remarkable affair. He had stewed a fowl, roasted a pig, and boiled a sheep, and the cook had then put the fowl in the pig and the pig in the sheep, making a compact piece of meat which, when skillfully carved, presented cross sections of all three principal parts, giving one, as he said, as interesting a view of internal structure as if it were a geological cross section.

From the hacienda the trail runs to the foot of El Bramador, where the famous sand dune is located which is the cause of the so-called “roaring” of the mountain. Leaving our riding mules

at the base, we climbed a spur of the mountain to the summit and obtained a general view of the valley (Fig. 46). The uppermost sand dune extends to within 100 feet of the summit. There is about 300 feet difference of elevation between the base and the top of the dune which lies in a natural hollow between two rocky spurs. It is perhaps 500 feet wide. The sand has been blown from the dry river bed and valley floor. It is not locally derived. The mountain itself is made of a dark volcanic rock. The sand is a light-colored quartz sand like that which is strewn so abundantly on the lower slopes of the valley and its floor.⁶²

We walked down upon the dune surface without hearing any noise whatever, the day being perfectly quiet. I had begun to doubt the reputation of the mountain, when I thought of starting a larger mass of sand in motion by rocking back and forth on my heels. The sand is piled up at an inclination of 30° , or about the "angle of repose," and it is therefore not difficult to send considerable masses of it rolling down the steep incline. Started at the top a quantity of sand will roll at least halfway and sometimes the whole distance down the dune.

As soon as I started a mass of sand moving down the slope there came up to me a distinct vibrating hum as nearly as I can describe it. It was about as loud as that which one would make in humming an air to oneself. When larger masses of sand were detached and sent rolling down the incline the hum increased in volume, and the crests of the sound waves under these circumstances seemed to fall about a second apart. I then tried pitching stones upon the surface of the dune, and when these fell in the steepest portion so that sand started rolling the same effect was produced. It is said that the sand will not make a noise when it is damp from the fog of winter. Though all of it was relatively dry, I was able to find some of it that contained a distinct amount of moisture. On experiment-

⁶² Comparison may be made with the famous Jebel Nagous of the Desert of Sinai, the subject of investigation by Dr. H. Carrington Bolton. Dr. Bolton describes the dune that gives forth the sound, "resembling the lowest bass note of an organ with a tremolo stop," as 390 feet from top to bottom, 260 feet wide at the base, and resting at an angle of 31° . (H. C. Bolton: *Researches on Sonorous Sand in the Peninsula of Sinai*, *Proc. Amer. Assn. for the Advancement of Science*, Vol. 38, 1889, pp. 137-140.)

ing with it I found that by stroking the sand with my hand downward at the surface of the dune and pressing lightly upon it by just a certain amount I could make the noise every time, whether the sand was hot or cold, dry or moist. I carefully ex-



FIG. 48—Photograph of a mirage at the foot of the huge sand dune that flanks El Bramador, or the Roaring Mountain of Toledo, near Copiapó. The camera is inclined downward at an angle of 30° . The dark slopes of the rock spur and also individual boulders appear to be reflected in a narrow sheet of water situated about an inch above the lower edge of the photograph.

perimented with this with watch in hand and found that the sand required stroking 15 times in 20 seconds to produce the effect, and there could be little variation from this period without the noise ceasing.

It appears that wind is not necessary to make the noise. Anything that starts the sand rolling will produce the rhythmic humming noise. When the wind blows it moves forward

in waves that produce a vibratory effect upon the sand surface. The noise comes to one then in strikingly rhythmical fashion. I was also aware of a distinct, though delicate and peculiar, vibration which seemed to come from the sand and affected my whole body when I stepped upon a fresh place and agitated the sand for the first time. I do not know whether this came from the crunching of dry sand particles under my feet or whether it is a matter of electrical tension. In any case, I had no instruments to measure it and only record the impression. The volume of the sound clearly depends on the state of the sand, whether it is piled ready to slide down at a touch on the steeper slopes of the dune or whether it lies on slightly flatter grades. At the time of an earthquake great masses slide down over each other as the trembling of the earth dislodges sand that the wind has piled up for days or months beforehand. This causes the vibration to be much louder and of longer amplitude, and it may then be heard a mile or so away. Naturally this has given rise to superstitions of one sort and another, and popular explanations given in the valley are that the noises emanate from caves in the mountain or from some concealed volcanic crater from which an eruption may some day arise.

CHAPTER VIII

THE INFLUENCE OF MINING ON A DESERT SETTLEMENT

For one hundred and fifty years after the first Spanish settlement Copiapó figured chiefly as a station on the north-south road, especially for the mule trains passing to Potosí, then at the height of its fame. The valley produced grain and fruits and was renowned for its wine. The production of this commodity and the exploitation of the pastures were in fact the industries upon which the early life of Copiapó depended. Characteristic both of the prominence of the wine-making industry and of the primitive simplicity of trade was the general use of the "arroba of wine" as the unit of currency. Other considerable industries were also related to wine making. The fabrication of wine jars stimulated the native pottery arts and concentrated the Indian population on the clay-yielding areas. Brea, a resin obtained from a small shrub growing in the border zones of the desert, afforded a varnish for the wine and spirit jars and was also exported as an ingredient of calk for ships. Similar uses of the brea may be found on the northern extremity of the great coastal desert, in the department of Piura. The brea shrub is also valuable as pasture, and it is not surprising to find the apparently unattractive "breadales" the subject of frequent litigation. Besides brea and wine, sulphur, early mined in considerable amount, and copper formed the principal commodities of a small export trade by sea that began in the mid-seventeenth century. The outlet for these products was Puerto Caldera, first mentioned in the archives in 1652-1653 when a boat is recorded to have carried 310 arrobas of wine to Coquimbo.

THE FIRST MINING: GOLD

In the early eighteenth century Copiapó was roused by the first indications of what was subsequently the most important

factor in its evolution—its mineral wealth. The gold of Copiapó had first attracted the Incas; the name of the valley, indeed, is by some authorities derived from the Quechua, “cup of gold.” Yet the gold of Copiapó was little worked in the early days when Chile as a whole was earning a great reputation for gold production.⁶³ Climatic conditions, by governing the available supply of water for washing, undoubtedly played a part in the retardation of gold mining in Copiapó. The first gold workings were begun by Hernando de Aguirre, son of the conquistador. Copper also was exploited to some extent, but the mining industry made little progress, in part for the reason advanced above, in part on account of the scarcity of labor and of the vastly superior attractions of Potosí.

In the early eighteenth century a change took place in the gold mining industry: the working of veins supplemented and succeeded placer mining. In Copiapó the new development effected a sudden transformation of the valley settlement. Rich veins were discovered at the old site of Jesús Maria to the north. Copiapó became known as the place where gold was “extracted by the basketful and weighed by the steel-yard.” People came from far and near, almost depopulating some of the neighboring valleys. From a wayside oasis Copiapó grew to the status of a town. In 1744 it was promoted to the rank of “villa” under the title San Francisco de la Selva de Copiapó.

In this new epoch of a fuller life Copiapó began to feel more keenly its restricted water supply. The mines made heavy demands on local resources, and the slow and difficult modes of communication precluded any considerable importation. Cultivation expanded to the limit of the water available. To increase the supply was a difficult matter: it scarcely appears to have been attempted, efforts not going beyond such measures as the cleaning and repairing of canals to conserve the existing supply. The records of the Copiapó Town Council present an extraordinarily vivid picture of the dominant control exercised by the water supply. “The eternal question of

⁶³ Alberto Herrmann: *La producción del oro, plata, i cobre en Chile desde los primeros días de la Conquista hasta fines de Agosto de 1894*, Santiago, 1894. The author makes a critical examination of previous computations: his conclusions as to production are shown graphically.

water was the main affair of life." The reiteration of the legislative measures becomes wearisome; townsfolk quarreled with hacendados; hacendados with native Indian cultivators; up-valley with down-valley. On occasion military force had to be called in. Changes were rung on the details of the turno and on the suppression of certain cultivations to the advantage of others. But no permanently effective laws were enacted; the measures were only expedients of the moment. Even the attempt of the able Governor O'Higgins to adjust the water supply on a more equitable basis came to nothing, and his attempt to introduce cotton cultivation likewise failed on account of drought.

While land communications remain poor, progress was made during the eighteenth century in the use of the sea as a highway. This came largely with the trade opening offered to French ships as a result of the War of the Spanish Succession. The export trade of Copiapó was promoted; Caldera became a recognized port,⁶⁴ although of it could still be written at the close of the eighteenth century, "The arrival of a boat was a novelty, and Caldera, usually devoid of people save Changos, became a scene of excitement. Merchants then repaired to port to receive their merchandise; citizens prepared to buy new goods, foundries despatched bars of metal; officials were in attendance to certify against stolen goods and see that no fugitive nun, wife or runaway son escaped."⁶⁵

THE SECOND STAGE: SILVER MINING

By the eighteenth century several silver mines were being worked in the Copiapó and Coquimbo districts, though few of them were really profitable. The riches of Potosí and Lízpez strengthened the native tradition that silver was generated in the "snowy cordillera," and this diverted attention away from the sub-Andean zone that was to become the great silver-producing region of Chile. Poor mining methods were responsible for the reckless squandering of the earlier labor sup-

⁶⁴ Avoidance of settlement on the immediate shore was long encouraged by fear, surviving from earlier days, of the attacks of pirates and freebooters—"Drac" and his followers.

⁶⁵ C. M. Sayago: *Historia de Copiapó*, Copiapó, 1874, pp. 189-190.

ply. Capital was difficult to secure, and there were metallurgical problems to be met. It was not until the nineteenth century that the original handicaps were overcome and the mineral industry placed upon a sure foundation. Among all the handicaps, that of climate was probably most severely felt.

THE CLIMATIC HANDICAP

Farmer, muleteer, and miner were equally and vitally affected by the question of a water supply. During times of greater water supply new routes and new fields of exploration became possible, and there was more extensive travel and prospecting by muleteers and woodcutters as well as by the *cateadores* (prospectors) themselves. New indications of the presence of ore were revealed by rain wash on the hill slopes. Gilliss reports that of 495 silver mines denounced in Atacama in 1850, 381 were discovered between March and September, that is, in the rainy season, a time likewise favorable for pastures for the prospector's mules. The years preceding the discovery of Chañarcillo were marked by unusually heavy rains.

On August 19, 1845, the rain that had alternated with snows in the foothills in June and July at length reached the valley of Copiapó. Rain fell during a period of five hours, which was equal to a period of three hours of heavy rain. In fact, on the cultivated land the rain was equal to half an irrigation. As in so many other instances, the hills between Copiapó and the coast had a heavier rainfall than the valley. Directly after the rain an expedition was sent from one of the mines to the port of Obispito to explore the main track and all accessible tributary ravines and thus to see if the rainfall had been sufficient to start the vegetation again and enable the mines to transport to the coast a large quantity of ore that had been locked up for many years at great loss for want of forage to start the pack mules. The last pack train to reach the coast had made the journey in 1839, and it was natural that the directors of the mine should feel anxious as to the continuance of their venture.

In October, 1845, the manager of the Copper Mining Company of Copiapó was able to report that he had finally con-

tracted with the carrier to transport ore to the coast, though only because of an understanding that the contractor had the privilege of transporting as much ore to the port of Obispito (north of Caldera) as the season would admit of. There was a stipulation that the lightest of the cargo could go to Obispito, but the rest could be taken to Copiapó. In carrying out this contract, it is interesting to note that the contractor gathered together a force of 250 mules and carried 3000 quintals in seven trips lasting from the 13th of October to the 16th of November. It appears that a good deal of strategy was required even with a fair season, such as the contractor enjoyed in this instance, to prepare the troops of mules for the arduous journey to the coast. They were given three weeks' rest with good pasture before starting, and the cargoes were carried by alternating troops, one troop resting in some accessible ravine where water occurred while the other troop was carrying the load forward to the next stopping place. Even under these circumstances the contractor lost twenty mules, and the rest were unfitted for some time for further work. Yet the distance to the coast from the particular mines involved in the contract was but fourteen leagues.

It seems little that the desert dweller asks in the way of rain. In the valley of Copiapó a few hours' rain in May or June followed by a few hours in August insures a good spring; and in former times it enabled the ores to be carried with facility from every quarter, because sufficient water and wild herbage would be encountered for months afterward on almost every trail. When a favorable season occurred all the transport power was shifted to mines that were unfavorably situated. This was because ores could be shipped at all seasons from the port serving Copiapó, but where shipment was made from such ports as Chañaral and Paposo the surf and the prevalence of westerly winds prevented the loading of ores from June to September. Even the month of May was considered rather late.

Here again was a complication due to the circumstance that these so-called ports were ports in name only—merely groups of huts inhabited by an insignificant population, without any commerce worthy of the name, and with no strategic position

at the end of trade routes to the interior. The result was that the mining companies had to maintain troops and mules in readiness for an emergency; and with them they also supported asses, because in the worst seasons and the worst localities these were preferable to mules, since they could live on coarse wild herbage while the mules required alfalfa.

MINING TYPES

The nomadic types associated with Chilean mining are interesting, for the usual privations of a mining life here find one of their most intense expressions. The liberal Chilean mining laws with their democratization of mining property have favored the development of the *cateador*—the mine prospector; the tireless searcher of the hills, who, “migratory as the condor or huanaco, has the frugality of the saints and the iron frame of the conquistadores.”⁶⁶ In former days mining owed practically everything to the *cateador* working on his own account, but now with the introduction of capital he is chiefly engaged on the account of others, from whom he receives a share of his discoveries and by whom he is equipped and his family supported in his absence. He sets off on his journeys supplied with *charqui* (dried beef), water, a few simple tools, and his own stock of empirical knowledge. Often he is cheated out of his rightful rewards; and even if he is successful he will surely dissipate his fortune. Practically all the discoverers of rich mines have died in extremest poverty.

Isolation and the predominant part played by chance has saturated Chilean mining with superstition and tradition. The *derroteros*,⁶⁷ or descriptive plans showing the locations of mines, are fascinating as the fiction writer’s hunt for buried treasure: the desert abounds with the “*cerro encantado*” and the “*cerro de plata*.” Resembling the *cateador* in many respects is the desert guide, the *vaqueano*. He possesses the *cateador*’s powers of endurance and the sense of topographic detail that comes of long practice and familiarity. His re-

⁶⁶ B. Vicuña Mackenna: *El libro de la plata*, Santiago, 1882, p. 250. See also Ferdinand Gautier: *Chili et Bolivie*, Paris, 1906.

⁶⁷ Sayago, *op. cit.*, pp. 375-426.

sponse to the arid climate with its extremes of heat and cold is similar to the Arab's; his two ponchos, the thin one for day travel, the thick one for night, corresponding to the two weights of burnous. As in other primitive industries, where the element of "luck" figures prominently, control by beneficent or malignant influences is a firmly held belief: the number of mines named after the saints is significant. The stress of physical circumstances has not only molded the religious beliefs of the miner but has wakened in him a poetry of the desert, an appreciation of natural phenomena in somewhat the same way that a seafaring life does. For the miner on his day's work the dissolving mists of the morning are "las amantes del sol;" the tiny drops of dew, so precious on the coast hills, "lagrimas de la Virgen." The appearance of snow on a well-known desert peak is interpreted, "Dona Iñes está de novia."⁶⁸

But there are less attractive sides to the mining business. The cateador without luck is apt to turn *cangallero*, receiver of stolen metals—in the old days a good, even an honorable, pursuit but one now looked upon with little favor. And little love is lost on the *porunero*, the speculator who cheats all alike. In all the large mining camps the usual abuses have been present. The first silver exploitation in Copiapó was followed by such undesirable social results that the town council drew up protective measures, including the ringing of a curfew. The introduction of members of that "army of uitlanders" from whom the mines are recruited is unfavorably reported by the manager of the Copiapó Mining Company in 1838. "Before the discovery of the rich silver mines of Chañarcillo and other silver mines the population of the whole district of Copiapó was something below 4000 souls, as docile as any people in the world but sadly addicted to laziness and gambling—it has since increased to 12,000, the increase of 8000 at least the men, chiefly consisting of the most objectionable characters from all parts of Chile and the Argentine provinces and, from the sad mixture during seven years, the original inhabitants have become as corrupt and reckless as any of the newcomers."

⁶⁸ F. J. San Román: *Desierto i Cordilleras de Atacama*, 2 vols., Santiago, 1890, reference in Vol. I, p. 24.

Darwin wrote of the place in 1835: "Every one seems bent on the object of making money, and then migrating as quickly as possible. All the inhabitants are more or less directly concerned with mines; and mines and ores are the sole subjects of conversation. Necessaries of all sorts are extremely dear; as the distance from the town to the port is eighteen leagues, and the land carriage very expensive."⁶⁹

In the department of Copiapó, according to the census of 1875, there were 5058 foreigners, or one to every five nationals. Half the population dwelt in the "valley."⁷⁰ Philippi in his journey through the Atacama Desert learned that in 1853 there was not a single *cura* (priest) in the entire province of Atacama. He found that in Chañarcillo, with a population of about 5000 souls, 3763 had been punished by fine or corporal chastisement during a period of 39 months.⁷¹

THE GREAT SILVER DISCOVERIES

The great silver discoveries commenced in 1811 with that of Agua Amarga immediately south of Vallenar.⁷² A great spurt was given to the agricultural industry of the valley; new canals were cut, more land was put under cultivation, and the population of Vallenar town itself quadrupled in a short time. When Gilliss visited Vallenar in the fifties he found the town of 3500 inhabitants on the decline, for the mines upon which they had been so largely dependent for support were exhausted. The Agua Amarga discovery was followed in 1825 by that of Arqueros on the road from Huasco to Coquimbo. So important did these mines prove that two years after their

⁶⁹ Charles Darwin: *Journal of Researches into the Natural History and Geology of the Countries Visited during the Voyage of H.M.S. Beagle round the World*, 2nd edit., London, 1860, pp. 354-355.

⁷⁰ On the demography see an interesting series of papers by Dr. Ricardo Dávila Boza: *Geografía Médica: Revista Médica de Copiapó, Bol. de Medicina*, Santiago, Vol. 3, 1886-1887, pp. 379-384; 424-430; 479-480; and 505-512.

⁷¹ R. A. Philippi: *Viaje al Desierto de Atacama hecho de orden del gobierno de Chile en el verano 1853-1854*, Halle, 1860, p. 101.

⁷² The first silver mines of the desert worked on a large scale—because of proximity to the coast—were those of Huantajaya and Santa Rosa, seven miles from Iquique. These mines were discovered in the sixteenth century but abandoned soon after, to be rediscovered and extensively worked in the early eighteenth century.

foundation the government decreed the foundation of a mint in Serena, an event comparable with the creation of an independent mint in Nevada by the government of the United States subsequent to the silver discoveries of the sixties. The Agua Amarga and Arqueros mines exercised the most pro-



FIG. 49—Statue of Juan Godoy, discoverer of the silver mines of Chañarcillo, on the Alameda, Copiapó. The inscription on the statue reads: Juan Godoy descubrió el mineral de Chañarcillo el 19 de Mayo de 1832 cuya fuente de riqueza ha elevado á Copiapó á la altura y engrandecimiento en que hoy se halla.

nounced influence on the Huasco and Coquimbo valleys. The turn of Copiapó came next.

In the Alameda of Copiapó stands a bronze statue of Juan Godoy. Eighteen miles southeast of the town on the old Huasco road Godoy enjoys a monument "more lasting than bronze"—the famous hill of Chañarcillo. The Chañarcillo mines, of such importance in the history of Copiapó, were discovered in 1832 by the woodcutter Juan Godoy. The mines proved extraordinarily rich, especially in masses of nearly pure silver—one, for example, weighed 6000 pounds. In less than ten years the mines yielded over 12,000,000 pesos. With the

mushroom growth of a mining center a town sprang up: "On the plain beneath, the village or town of the Placilla, or Juan Godoi, is flourishing, . . . upward to the very summit of the hill, which is about 4500 feet above the sea, the whole steep scarp appears studded with immense steps of débris, with huge buttresses to support them; these are the mouths of the various mines. Perched on these resting-places are discerned the numberless houses, huts, and other belongings of each 'mineral,' and the whole mountain seems covered with them," wrote Colonel Lloyd in 1853.⁷³

Sixteen years later (1848) a muleteer carrying ores between Copiapó and the port of Flamenco discovered Tres Puntas. Lloyd has given graphic descriptions of the hardships encountered, here as elsewhere in the Chilean desert, from the scarcity of water. At first no water was known within thirty leagues of the mines, and a 9-gallon cask of brackish water cost \$8. Subsequently drinkable water was found in wells five and ten leagues from the mines and retailed for one-eighth of the original price. Yet in five years there had sprung up a town of 4000 souls.

The latest of the great silver discoveries was that of Caracoles, a traditional "cerro de plata" effectively brought to light in 1870. Caracoles lies on the road from San Pedro de Atacama to Antofagasta in the hilly basin west of the Cordillera Domeyko. Although at an elevation of 3000 meters (10,000 feet) precipitation is extremely light. At the end of the rainy season of the plateau, that is towards the end of April, an occasional cloud may detach itself from the masses that gather round the summits of the cordillera and produce precipitation, usually in the form of snow but so slight that it evaporates without producing any effect upon the ground.⁷⁴

In the extent of its widespread influence Caracoles was perhaps the most important of the discoveries. Its progress has been described in detail.⁷⁵ In 1870 Caracoles was simply a

⁷³ J. A. Lloyd: The Mines of Copiapó, *Journ. Royal Geogr. Soc.*, Vol. 23, 1853, pp. 196-212; reference on p. 199.

⁷⁴ Felipe Labastie: Estudio sobre el mineral de Caracoles, Santiago, 1901.

⁷⁵ André Bresson: Bolivia, Paris, 1886, pp. 300 *et seq.*

A. Pesse: Le district minier de Caracoles, *Bol. Soc. Géogr. de Paris*, Ser. 6, Vol. 7, 1874, pp. 177-181.

house of loose stones and a tent. In 1871 it began to be a village, chiefly of tents of wretched appearance. In 1872 there were 2000 inhabitants, and houses were being built of wood or galvanized iron; streets were well aligned. In 1873 commercial houses on the coast established branches here, hotels were erected, and the streets paved. In 1874 it was a well-ordered town of 2500 in the center of a fast-growing district. Yet in nothing was the town self-supporting. The nearest source of drinking water was the wells of Aguadas Dulces 12 kilometers (7 miles) to the northeast, whence it was brought daily by cart. San Pedro de Atacama and other towns of the western slope of the cordillera provided firewood and fruits and some meat; cattle and fodder came over the cordillera from Argentina. Calama also sent fodder. Other things came by Antofagasta, the nearest port and the one whence the ore was shipped.

The cost of transportation was tremendous in any direction. It is said that from the coast to the mines the freight charges were double those by steamer from the port to Europe. The scale of traffic under these circumstances can be appreciated from the fact that at the height of prosperity 1500 carts, each drawn by 5 to 6 mules, were regularly employed between Caracoles and Antofagasta. There was a notable distinction between the journeys on the uphill and downhill grades: whereas the former took 4 to 6 days the latter took only 3 to 4.

The mining men at Copiapó refer facetiously to a place at some distance as 25 leagues up the valley and 4 leagues down. Uphill and downhill rates differ greatly in almost all countries where there is primitive transportation. It is estimated that the cost of downhill traffic to Puquios, where the Dulcinea Mine ships its copper ore, is to the uphill traffic cost as two is to three. The flux being near the station to which they ship their matte, there is provided cargo both ways.

COPPER MINING

The first copper mining in Chile, apart from pre-Spanish mining, was for the purpose of supplying artillery for coast defense. In 1600 García Ramón was not permitted to carry

cannon with him from Peru to Chile, for the latter country had abundant raw material. In the seventeenth and eighteenth centuries copper was shipped from Coquimbo—and less extensively from Copiapó—to Callao. Though nothing came of it, a proposal was made to establish an arsenal at the former place because of its greater accessibility to fuel. By the end of the eighteenth century many mines had been denounced and exploited, especially in the province of Coquimbo, but only the richest could be worked for any length of time: only those so rich as to yield at least fifty per cent refined copper, says Molina.⁷⁶

The influences coming into operation after the Revolution had as marked effects on copper mining as on silver. The market was enlarged, the price of copper raised, and the cost of production diminished. The diminution in the working expenses was chiefly due to the reduced prices of all commodities needed for the mines. Means of exportation improved also. Ships formerly bringing imports and returning in ballast began to find cargoes. For a time the triangular movement to the Orient was encouraged, although the Calcutta trade was dropped in 1835. American vessels bound for China called at Valparaiso for copper. If they were unable to complete their shipload at this port they proceeded farther north to Huasco and Copiapó.⁷⁷ Ships sailing to Buenos Aires and unable to obtain cargoes began to round the Horn to Chile. The time (1840) was ripe for the introduction of steam navigation. As early as 1829 Wheelwright had established a regular line of sailing vessels between Valparaiso and Cobija. The Pacific Steam Navigation Company was founded in 1838, and the first two steamers started running two years later between Valparaiso and Callao. In 1846 the line was extended to Panama, where connection was made with Royal Mail steamers on the Atlantic side. In 1868 the line to Liverpool was inaugurated. Incidentally, because of the difficulty of obtaining fuel, the steam navigation stimulated exploitation of the coal mines of southern Chile.

⁷⁶ G. I. Molina: *Saggio sulla storia naturale del Chili*, Bologna, 1782.

⁷⁷ *Three Years in the Pacific, 1831-1834*, by an Officer of the United States Navy, 2 vols., London, 1835.

The introduction of the new navigation contributed much to the regulation of shipping. Previously transportation had suffered exceedingly from irregularity. Thus we are told that in 1824 Coquimbo was a wretched and dilapidated place, the harbor being desolate save for an occasional whaler or coaster and a casual vessel to take in copper.⁷⁸ Diego de Almeida told Philippi that he made his first shipment of copper from Chañaral las Animas by a whaleboat that chanced to put in the bay for water.⁷⁹ Freight charges had likewise been variable. When much shipping happened on the coast, freights went down; when little, they rose.

Another element that stimulated Chilean trade, both by carrying traffic round the Horn and by creating a new market, was the discovery of gold in California. The golden "años de California" are still a grateful memory. Chilean wheat was carried north and sold at high profits. Mackenna relates⁸⁰ that he himself sold in 1853 a 100 kilogram sack of wheat for 150 francs in San Francisco, when its original cost in Chile had been 62 francs. Ships making the return journey carried copper, for this was the beginning of the copper period.

THE COPPER PERIOD IN COPIAPÓ

The following figures, representing mines worked, indicate the mid-century trend of Chilean mining, typically illustrated by the department of Copiapó to which the figures pertain:⁸¹

	1806	1850	1853	1866
Gold.....	13	6	17	0
Silver.....	7	235	509	177
Copper.....	4	14	116	199

The effect of this development on the general progress of the country may be gauged by the trade figures of the time. In

⁷⁸ Thomas Sutcliffe: *Sixteen Years in Chile and Peru from 1822 to 1839*, London, 1841, p. 105.

⁷⁹ Philippi, *op. cit.*, p. 12.

⁸⁰ B. Vicuña Mackenna: *Le Chili*, Paris, 1855, p. 55.

⁸¹ P. L. Cuadra: *Jeografía física i política de Chile*, *Anales Univ. de Chile*, Santiago, Vol. 31, 1868.

1864 the foreign and domestic commerce of Atacama, amounting to over \$20,000,000, represented 20 per cent of the total for the entire country, whereas the population represented only 4 per cent. The foreign import trade was distributed almost exclusively between Argentina, 63 per cent, and Britain, 23 per cent. The chief commodities sent by the former were cattle (\$529,999) and mules (\$49,000), from the latter, coal (\$198,500). The foreign export trade was practically all with Britain (92 per cent), North America taking 6 per cent. Caldera was the center of this trade. With its dependent ports, that is, the points on the coast where copper was shipped, it accounted for four times as great a volume of trade as Huasco and its minor ports, in both cases the trade through the inland "ports" of the cordillera being included. Although the population was low in proportion to the area, it showed a remarkable increase over earlier figures. Towards the end of the eighteenth century the population of the *partidos* (of the bishopric of Santiago) of Copiapó and Huasco had been estimated at 8000. The census of 1865 credits the Province of Atacama with a total of 77,453, the highest attained (see Table III). In that year Copiapó town numbered 13,381, also a maximum.

TABLE III—POPULATION OF THE PROVINCE OF ATACAMA ACCORDING TO SUCCESSIVE CENSUSES

DEPARTMENTS	1865	1875	1885	1895	1907	1920
Chañaral.	4,425	4,961	5,558	4,321	6,057	5,149
Copiapó.	44,670	35,807	29,705	26,310	27,315	20,689
Freirina.	14,912	15,541	13,434	12,868	12,722	6,480
Vallenar.	13,446	13,569	15,446	16,214	17,874	16,095
PROVINCE.	77,453	69,878	64,143	59,713	63,968	48,413

Among the principal results of the mining activities were the creation of a new economic movement and of a new means towards movement. As the foregoing has shown, transportation was one of the most serious problems in the development of the mines. The mines of the Copiapó region had to provide their own means of conveyance. In this roadless, well-nigh waterless, country their choice was limited to the hardy en-

during mule or the less powerful but even more abstemious burro. Supply of these animals had to be replenished constantly, for under the hard conditions of desert work they are very short-lived. Argentina is the great basis of supply not only for this means of transportation but also for one of the important food requirements of the mines—cattle, a commodity that can move itself to market. Cattle also come from the south of Chile. As far north as the Coquimbo valleys it is common to find the large farmers with two complementary farms—the small, irrigated, intensively cultivated hacienda in the lower valley and the range, or estancia, on the mountain spurs with pasture dependent on rain. Cattle from the estancia are brought down to the hacienda for a few months' fattening before shipment north to the mines. Farther north the oases of both the desert and the puna carry on a like profitable business with cattle brought across the cordillera. Huasco, Vallenar, Copiapó, Calama, San Pedro de Atacama, all derive an important income from the system of *talaje* as it is called.

THE COPIAPÓ RAILROAD

The mines first brought the railroad to Chile. The Caldera-Copiapó line, fifty miles long, built by William Wheelwright, was the first important line to be constructed in South America.⁸² It was opened to traffic on December 28, 1851. Subsequently the line was extended to Chañarcillo, and its builder projected its continuance as a trasandine line to Rosario on the Paraná. In pointing out the advantages of such a line he gives an interesting example of the costs of transportation involved from the cordillera to the plain. Salt from the intercordilleran salars is sold in Copiapó at \$250 a hundred pounds. He estimates that it could be delivered at Los Chilenos, a point on the projected line, for 50 cents, and thence "the action of gravity alone would take it to Copiapó on the railroad."⁸³ The opening of the railroad brought about distribu-

⁸² The oldest line on the continent is the Georgetown line, British Guiana, opened 1848; it is only 5 miles long. The Lima-Callao line, another short line, comes second, having been opened in April, 1851.

⁸³ William Wheelwright: Proposed Railway Route across the Andes, *Journ. Royal Geogr. Soc.*, Vol. 31, 1861, pp. 155-162; reference on p. 160.

tional changes in the lower valley. Caldera, once the port of Copiapó, had fallen into disrepute and had been replaced by a port at the mouth of the Copiapó valley. Now Caldera was resurrected, Puerto Viejo being abandoned in its turn. Caldera with 50 people in 1850 had 2000 in 1853. With the passing of the mining booms towards the end of the century Caldera again declined, and now, in spite of its fine natural harbor, a rare feature on the North Chilean coast, it is of little importance with only 2000 inhabitants.

Another interesting response to the railroad was the drop in the value of land that followed its construction. Until the nitrate development in the north began to make its heavy demands on the products of the northern valleys, property in the Copiapó valley had realized its highest values in the decade before the opening of the railroad transformed the means and costs of transportation. Cuadra cites the case of a piece of land near Copiapó about an acre in extent from which the annual value of the forage averaged \$800. Gilliss also instances a price of \$4000 paid for the alfalfa cut from less than four acres, though this was in a dry year (1850).

The opening of the Copiapó railroad was an important event for the Dulcinea Mine of the Copiapó Mining Company. It released mules from the Copiapó-Caldera transit for service between the mine and the town. This was the more difficult stretch, however, for the roads were much worse, a fact reflected in the carriage rates between the two sections which in the early days were in the ratio of 11 to 16. Greater advantages accrued from the continuance of the line in 1871 to Puquios, only a few miles from the mine. The more northerly group of Las Animas gained likewise from the opening (1870) of the line from the Bay of Chañaral and the branches subsequently built.⁸⁴

The famous Dulcinea Mine is at an elevation of 6600 feet and has a maximum depth of 3600 feet. Since the recent installation of a smelter at the mine, ores have been worked down to 7 per cent assay or less where previously 10 to 15

⁸⁴ J. G. Matta: *Bosquejo del estado actual de la industria minera del cobre en el extranjero i en Chile*, Soc. Nacl. de Minería, Santiago, 1915.



FIG. 51



FIG. 52

FIG. 51—Looking west at the desert ranges between Puquios and the Pacific coast, near the Dulcinea Mine.

FIG. 52—The smelter at the Dulcinea Mine near Puquios, northeast of Copiapó.

per cent was required.⁸⁵ The production per month in 1913 averaged 2000 tons of ore. In former days ore was sent to Swansea, on the western edge of the South Wales coal field. It is now sent to New York chiefly. A few other productive mines exist in the vicinity of the railroad, but there are also a considerable number today paralyzed by high freight rates that could be profitably worked if in touch with a railroad. The small mines suffer, too, from lack of capital to tide over bad seasons. This is one reason why the Copiapó Mining Company has been able to establish the unique record of a continuous existence for a century. Furthermore, the small mine is extinguished by a fall in the market. Capital is the chief hope for revival of the industry that attained its maximum development in 1876.

Overshadowing the smaller operations once characteristic of Chilean mining are the great copper mines of Braden, south of Santiago, and of Chuquicamata, near Calama. Deposits of ore of mountainous proportions are worked in both places by modern mining and metallurgical plants representing an investment of capital on a large scale. The technical methods employed enable the use of low-grade ores, and the scale of the enterprise supports a lay-out of roads, railways, and port facilities which the scattered and smaller mines of earlier years could not command.

THE RECORD OF A HUNDRED YEARS

At Copiapó I had the good fortune to discover a great mass of buried treasure in the form of records and correspondence extending over almost a hundred years, and pertaining to the affairs of the Copiapó valley and especially the business of the principal copper mining company here. The present name of the company is "The Copper Mines of Copiapó, Ltd." In the early days of its history it was called "The Copiapó Mining

⁸⁵ Singewald and Miller give the instance of the Esploradora Mine in the department of Chañaral, where the product shipped in 1913 averaged 20 per cent copper. "More than 75,000 tons of 7 to 8 per cent copper ores remain in the dumps." The ores have to be hauled 125 miles by cart. (B. L. Miller and J. T. Singewald, Jr.: *The Mineral Deposits of South America*, New York, 1919, p. 253.)

Company." Through the courtesy of Mr. F. N. Perkins, the General Manager of the mine, I was permitted to examine the contents of forty or fifty large wooden boxes which contained bundles of letters and records the originals of which had been sent to the directors of the company in London. The discovery of the material was particularly fortunate because the successive general managers or superintendents of the copper mines appear to have been exceptionally intelligent men, and in addition to reporting on the mining properties they were of necessity obliged to report upon the state of the river, the occurrence of rains and unusual snowstorms, damages done by flood and drought, the condition of the trails and the pastures and springs along them, the state of the ports, and the conditions of land transportation and shipping.

For a long period about the middle of the last century a Mr. Bingley was general manager of the company, and his descriptions are of the greatest geographical and historical interest. He is quoted by Darwin, whose paragraphs clearly reflect the quality of the correspondence: "I had a letter of introduction to Mr. Bingley, who received me very kindly at the Hacienda of Potrero Seco."⁸⁶ In many letters long accounts of the country and the people are interspersed with more technical matters. It was clear that the explanations he gave were of great value to the directors of the company in London, for upon them could be based explanations to the stockholders, particularly of the unsuccessful years. In addition to these reasons the company had during part of its history to supply its own transport mules and manage the conveyance of its ores to the coast and their shipment overseas. Whatever the state of the pastures in the valley and whatever difficulties there were over water rights would naturally be touched upon because they bore not only upon the principal business of the company but also upon the subsidiary business of farming and grazing carried on to maintain the means of transport.

As the population increased and transport conditions im-

⁸⁶ Charles Darwin: *Journal of Researches into the Natural History and Geology of the Countries Visited during the Voyage of H.M.S. Beagle round the World*, 2nd edit., London, 1860, p. 350.

proved, and particularly after the building of the railway line in 1851, the effect of natural conditions upon the mining interests and more especially upon agricultural and grazing interests received less and less attention in the reports of the successive general managers of the mines; and in the last few decades the reports become constantly briefer as difficulties are taken for granted and as modern machinery is introduced to solve many of the other difficulties under which mining was conducted in this frontier province. The effect of natural conditions is still felt, but they are made less of by business enterprise. The officers of a mining company today look at the production of ore rather than study the environment in which the men work who produce the ore. The modern view is that the only important thing is the actual output of the mine—all the rest is detail which the general manager must handle as best he can.

Having in mind the frequency of earthquakes and the accompanying risk of damage by fire, I felt it wise to make an abstract of much of the correspondence. I do not know whether the violent and destructive earthquake of 1922 left these old records intact or whether they have since been destroyed; but the originals, many of them containing maps referred to in the notes, have recently been destroyed by the home company in London on account of lack of space. I took twenty-five pages of notes, and these I have deposited in the archives of the American Geographical Society, where they may be consulted. While many of the data in these notes have been worked into the ensuing narrative and description, there are additional details in the notes that might be of interest to historical students. I will give a few selected illustrations merely to indicate the quality of the material.

After a discussion of the struggle which took place in 1862 for water rights and comments on the rich harvest that the lawyers expected to reap and on the old documents and still older traditions regarding water rights, the directors are informed in a letter dated April 2, 1862, as follows:

“When we consider the immense value of the water in these deserts and that in a few hours, more or less, of irrigation

monthly the value of an estate rises or falls thousands of dollars, the eagerness with which these questions are debated may be pardoned."

There are comments on the cattle trade, the pasturing of flocks and herds afield, on the revolution of 1851, the year in which the railroad came to Copiapó, and the effects of the War of the Pacific (1879-1883) upon business and the cattle trade generally. Thus in 1879, the year in which the war began, few cattle came over the cordillera because the dealers were selling more profitably to the armies in the north. A Peruvian squadron was reported to have cruised along the coast in the latter part of July and to have destroyed the launches, used in lightering cargoes from ship to shore, at Taltal, Pan de Azúcar, Chañaral, Carrizal, and Huasco and to have been kept off Caldera on account of the guns established there for the protection of the port. There is an account of the conditions under which the port was changed from its old location at the mouth of the Copiapó River to its new location at Caldera. It seems as if every important shower was reported in the correspondence. It was noted that Welsh miners were imported and that the beginnings of steam navigation on the west coast gave great stability to shipping hitherto most irregular in quantity and availability, the ores being accumulated at the ports and shipped whenever empty vessels called. Rarely was a boat sent over for the express purpose of bringing back ore, as in later times.

Not the least interesting entry is one under date of February 16, 1844, in which the manager points out the popular belief in Copiapó at that time that the English were heretics and only the people of South America were Christians. A native of Copiapó accused of a fraud against an English house at Valparaíso presented an *escrito*, or writing, to the court which insisted that the testimony against him of two persons, being English and consequently heretics, amounted to nothing, for it was made against himself, a *Cristiano*, and cited legal precedence in support of his position—more than a faint echo of two and three centuries before.

An old map without date was attached to one of the letters

written by George Bingley to Messrs. Robert Scott Fairlie and Company of London and dated April 30, 1835, so that the map cannot be more recent than the date of the letter, and there is evidence that it is older than the letter, for the name Flamenco, one of the tiny copper exporting ports of the coast, is inked in

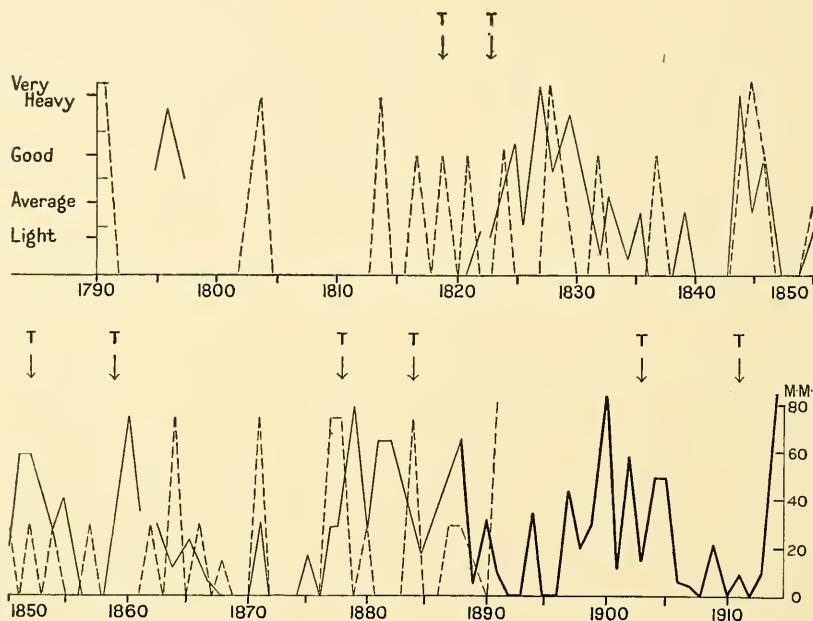


FIG. 53—Rains at Copiapó are shown by a solid line. The heavy line indicates figures from the continuous series of official meteorological records. The light line indicates deductions from records of the Copiapó Mining Company, the *Anales de la Universidad de Chile*, the *Historia de Copiapó*, and other sources. The dashed line shows the rainfall of Piura deduced from various historical sources by Victor Eguiguren (*Las lluvias en Piura*, *Bol. Soc. Geogr. de Lima*, Vol. 4, 1895). Floods in Tarapacá are indicated by the letter T.

on the map instead of being printed like the rest (Fig. 50). The border of the map is colored green by means of a wash applied by hand. A similar wash of blue was laid over the border of the sea and over a few supposed lakes near Huasco. Four irrigated farms of the copper company on the Copiapó River are colored dark green. The company's mining properties are indicated by colored squares, and the names are under-

scored in red ink. An interesting feature of the map is the position of the northern boundary line of Chile, which is placed at about latitude $25^{\circ} 30' S$.

Upon the basis of the wet years reported in the correspondence over a period of nearly one hundred years I made a rough "curve" to bring out the period of recurrence of the rains (Fig. 53). The general manager of the chief mining company expressed great interest in the curve showing past conditions but still greater interest in the next rainy season. Far from being above the need of such knowledge, he said he was as interested as any of his predecessors, first on account of the forage required for the mules that hauled the matte carts to the railroad and brought ore from the small mines round-about to the smelter operated by his company at the Dulcinea Mine, and second because he was drilling a well to tap the ground water in the small basin whose exit is near the smelter. The lack of water had been one of the standing difficulties in the successful operation of the mine. At a venture I projected the rainfall curve and told him that 1914 ought to be a wet year. A year later, in June, 1914, he wrote me as follows:

"You will be pleased to learn that your prognostications . . . have now been confirmed. The Copiapó River has been very swollen, the greatest amount of water within the last fourteen years, while on the 15th inst. the Copiapó district had the benefit of a copious rainfall. This information to you will have great scientific interest—to us great benefits will ensue."

CHAPTER IX

EASTERN BORDER TOWNS

APPROACH ACROSS THE ARGENTINE PAMPAS

Where the plains or pampas of Argentina break with the mountain country on the northwest we find the life a curious blend of the frontier and of long-established conditions, as if all the settlements were breaking out of one age into another. The oldest Spanish settlements in Argentina were made in these remote northern valleys at the border of the plain, yet the region seems today a border country like our West when railroad building was at its height. It is only in the last two decades that the high pastures of the upper mountain slopes and valleys and basins have been intensively developed. Traffic has been carried on by primitive means that prevailed from the beginnings of Spanish settlement. Even the oxcart is absent from most lines of communication. Here for four hundred years the pack mule has been the chief dependence of the merchant. Towns old in history, important in trade, repeatedly mentioned in the annals of the past four centuries have still no means of communication with the outside world except such as the mule and the burro afford. The contrast between old and new is not alone in the valleys on the mountain border, it extends into the plain. Where the streams from the higher country spread their waters and their rock débris out over the edge of the flat land of pampa, sugar estates have been developed and towns, the leading centers of the region, like Catamarca, Andalgalá, Tucumán, Salta, and Jujuy. And these too have a life as strikingly changeful as if their founding were a modern event instead of a fact four centuries past.

To take the route to the northwestern frontier from the Plata is to discover some new things by the way. On leaving Buenos Aires the railroad passes through typical pampa—not

flat but gently rolling. Groves dot the plain so that half the horizon or more is filled with them, much as the woodland clumps in our Middle West fill the horizon, only the groves are thinner and more distant. They encircle all of the ranch houses and occasionally there are stands in the open. On leaving Rosario on the banks of the Paraná the groves become smaller and farther apart, so that the horizon is rarely interrupted by them. Instead of complete flatness, the pampa has great swells and alternating broad depressions, and a narrow belt just below the horizon is marked by delicately merging profiles. Standing at the crest of a gentle ascent and looking up it toward the horizon one sees a belt of plain occupied by a single field, strong in its details of wire fence, clumps of trees, rows of corn, or groups of cattle. Above and beyond that is the field in profile, and beyond this profile a gap. The next basin or shallow-valley rim that comes into the narrow belt of profiles just under the horizon is very distant and faint, and on it and succeeding profiles up to the horizon itself are abundant though dimly seen details of houses and clumps of trees, but the cattle and rows of corn are lost in all but the nearest slope. It is this contrast in the clearness of the details between two succeeding profiles seen almost edge to edge close to the horizon that makes the pampa seem so vast. There is no high relief to break the view, so that profile succeeds profile in seemingly endless fashion.

The true grassy pampas, wild, and bearing natural clumps of grass, with a little bare earth here and there, appear still farther west and north on the way to Tucumán. They are dusty, quite without trees except near the horizon where there is a stream or a settlement. Approaching nearer the base of the mountains bright green sugar-cane fields come into view, irrigating ditches, then the houses of the *hacendados* of Tucumán. Above the town and along the base of the mountains runs a belt of dark green chaparral and woodland—the *monte*. It consists of cedar, algarrobo, and quebracho, with cactus here and there, and other species of plants. It becomes dense and the trees large and valuable on the higher slopes, and lumber, railroad ties, beams, and the like, are produced.

Woodland mantles the mountain slopes for hundreds of miles toward the north, where it merges into the Chaco gallery forest, and extends also toward the south, where it ends in patches and narrow belts as the mountains become correspondingly dry in that direction (Fig. 86, p. 253).

A CROSS SECTION OF ARGENTINE LIFE

To go from Buenos Aires with its forest of spars in crowded ship basins, its beautiful plazas and avenues, and its modern facilities of every kind, out across the pampas to the city of Tucumán with its sugar industries and then up into the forest country and above it to the pasture land of the mountain zone, finally to reach the primitive habitations in the secluded valleys of the Puna de Atacama, is to see in cross section the life of Argentina. As a geographical picture it is unrivaled. It is, above all, a strongly featured section of life but little disturbed by eddies and cross currents such as one may see in the life of the United States. Argentina has no coal fields, and but very little oil has been discovered up to this time. Its forests are without exception in distant places. Their woods are of relatively little value for building purposes; they could not begin to supply the demand for lumber on the pampas and in the cities of the coast. Lumber and timber are imported from Scandinavia and from California, Oregon, and Washington. Lumber is one of the principal items of trade at the port of Buenos Aires. Argentina, still for the most part in the extractive stage of industry, has no manufacturing belt like England, the United States, Germany, and France, where groups of distinctive industries have been developed in close association with supporting mineral resources. Cornfields, wheatfields, alfalfa fields, fenced range, and after that open country of little value, semiarid as to climate; meager as to resources—this is the succession as one leaves the coastal towns. Then comes the mountain border of the plain, where irrigation brightens the landscape—a fertile belt, rich, specialized, accessible from the plain yet fed with water from the mountains. The sugar belt of Argentina is here. It runs from

Córdoba northward in spots and patches past Tucumán to Ledesma and well toward the Bermejo River and in time will probably extend in like belts and patches along the foot of the Andes all the way to Santa Cruz de la Sierra in eastern Bolivia and even beyond. There is a similar belt in the secluded valleys of eastern Peru at relatively low elevations where "playa" lands along the valley floors can be irrigated from the mountain streams.⁸⁷

The mountains of northwestern Argentina together with the high border valleys constitute a type of country totally different from that of the pampas border. In a narrow zone one may pass in a few days from warm valleys at 4000 feet to Andean ranges at 16,000 feet, through the belt of irrigation to the belt of woodland, the belt of grasses, and finally to barren mountain slopes and rock slides. The distinctive products of the high valleys and mountain pastures include skins, wool, blankets, wood. These come down in long pack trains to the bordering towns at almost all seasons of the year. I saw them in June above Molinos on the trail down the Escoipe ravine (Fig. 59). They were loaded with skins chiefly and with *habas*, a vegetable which is about twice as large as a bean and shaped somewhat like it and which was selling in Salta at \$1.80 per 10 kilos (22 lbs.). It is shipped to Buenos Aires annually in large quantities. Goatskins formed part of the mule cargo. They brought \$1.50 per kilo. From forty-five to eighty thousand and more kilos a year are shipped out of the single valley of Calchaquí. From the whole province of Salta it is estimated that 300,000 pesos in value of goatskins are exported. They constitute the item first in value in the whole province. Next come corn, potatoes, *habas*, and peas.

Many families once poor landowners with large but low-value estates in the mountain valleys of northwestern Argentina are now rich city dwellers. This is a phenomenon common enough in the eastern agricultural provinces of Argentina, but it is of recent development in the mountain provinces and in some cases is due to quite different stimuli: the railroad, the

⁸⁷ See the regional diagram of the eastern aspect of the Cordillera Vilcapampa, in the writer's "Andes of Southern Peru," New York, 1916, p. 68.



FIG. 54

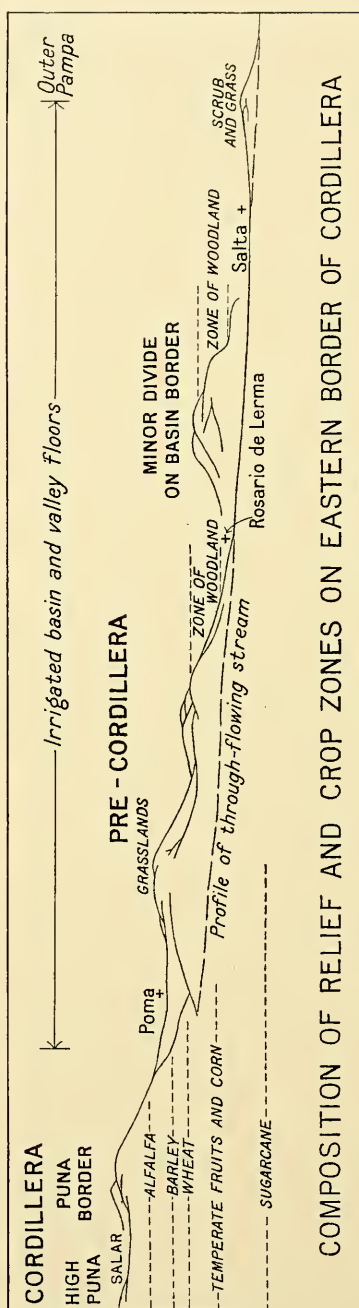


FIG. 55

FIG. 54—Panoramic view of the Salta basin; cornfields in the foreground, pastures in the middle distance, swamp along the river course. Note the characteristic belt of cloud on the upper slopes of the mountains and compare with Figure 55 below.

FIG. 55—The narrow woodland belt is characteristic; for a map of it consult Figure 86. Above and below the woodland are grass-land and irrigated agricultural tracts. The variety of life and trade is suggested by the suspension of these several zones in a relatively narrow belt on the mountain border.

growing nitrate industry in Chile which draws thither an important transmontane trade; the more rapid development of mining since the introduction of the railroad, and a host of minor and local causes.

SALTA: A FRONTIER TOWN

Because it is the capital of the province in which these economic changes have been most marked, Salta has been transformed in the last twenty years. From a mountain village it has developed into a fair-sized city. The population of the city according to the census of 1895 was 16,672; the last census gives 28,436, of whom 4505 are aliens. The *Departamento* of the capital had 16,887 in 1869; 20,361 in 1895; 33,636 in 1914. Salta's people were once untraveled, and its streets were filled with pack trains bearing supplies that were in large part bartered rather than sold. Even its merchandise only a few decades ago came largely from across the cordillera, where Chilean railroads gave easier access to important commercial routes. Now it has a street-car line, big business houses, at least four large banks, and a considerable number of really modern dwellings. He who has visited Europe is no longer pointed out as a distinguished person. The dresses of the women are nearly as modest as those to be seen on the streets of New York. One of the most elegant clubhouses in Argentina faces the well-kept plaza. The life of the people in a score of ways has taken on a degree of comfort and luxury hitherto almost unknown.

Salta lies on the floor of an intermont basin (just under 4000 feet above sea level) between two streams bordered by marshy tracts, or *tagaretes*, crossed by selected roadways. It is not at the end of the railway. This extends still farther west and south to the terminal station of Rosario de Lerma, a little town of slight commercial consequence with no modern merchandising facilities. It is at Salta that the business of the railway has its first marked development. There is first of all the exchange of commodities as in any frontier town on the border of two unlike regions. Flour is brought from Buenos Aires, sugar

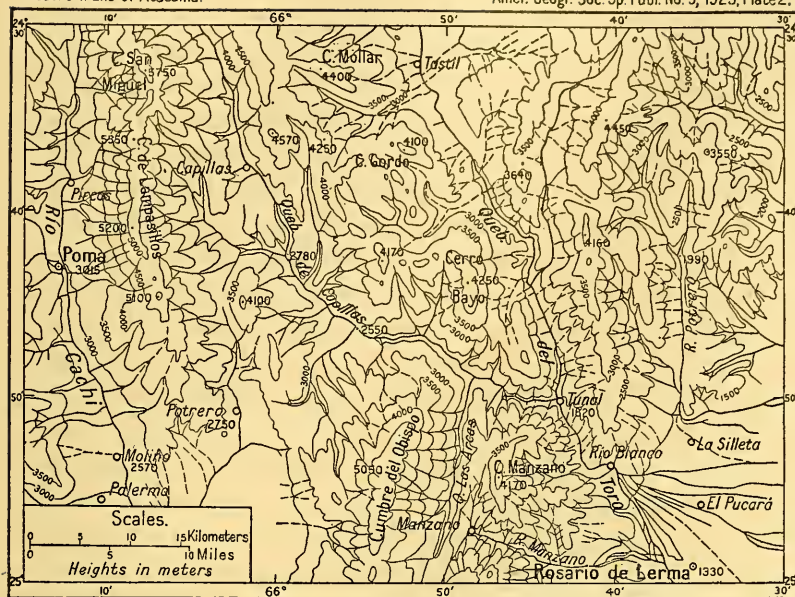
from the estates along the mountain border. Tobacco is obtained from the surrounding fields; brandy is imported from the sugar refineries; wine, rice, and building materials come from outside the district. The basin floor has a wealth of cornfields to feed the live stock bred in the basin and imported from the Gran Chaco—the grassy plains country of north-eastern Argentina and the region northward. Alfalfa is also produced to support the stock-raising industry. Cattle from the Chaco are turned into the alfalfa meadows and cornfields to be fattened for the journey over the cordillera to the nitrate oficinas or establishments of Chile; the staple product of Salta, now, as for the past three centuries, being live stock, a typical frontier product. Though the Lerma basin floor is intensively cultivated wherever drainage conditions make cultivation possible, and though it has thus every appearance of fertility, the soil is much underdeveloped and could be greatly improved by better drainage and better irrigation methods. Only one per cent of the total area of the province is under cultivation. It is this aspect, as well as the character of the trade and the manner in which it is conducted, that gives Salta a characteristic frontier appearance. As a further mark of its frontier character, there still remains the great fair, which annually meets in July and which was held formerly in the town and now is held twenty miles or so to the south at Sumalao.⁸⁸

MULE TRADE AND TRANSPORT

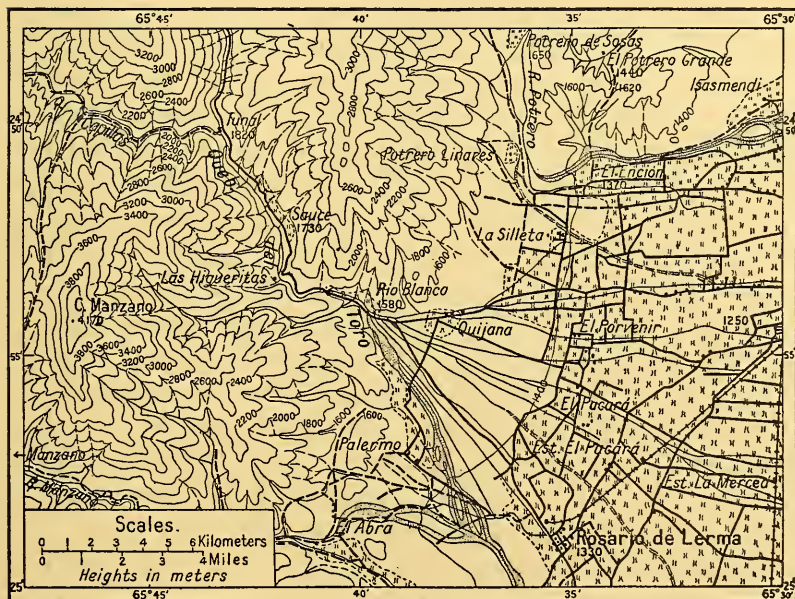
It was in the seventeenth and eighteenth centuries that the great fair of Salta won its most substantial reputation. The stock bred in vast numbers on the pampas of the Plata country

⁸⁸ G. M. Wrigley: Salta, an Early Commercial Center of Argentina, *Geogr. Rev.*, Vol. 2, 1916, pp. 116-133.

PLATE 2A (opposite) represents the Rosario de Lerma sheet of the Mapa Geológico-Económico de la República Argentina, 1919, scale 1:200,000, reduced and simplified. The map shows the character of the eastern border of the mountains. Plate 2B is the lower right-hand corner of the upper map enlarged to show drainage, irrigation, and towns in detail. The shaded area represents cultivated land.



A



B

was disposed of in two ways. The cattle were valued chiefly for their hides, and for a time their bones also had considerable value. Their use for meat and milk was local and insignificant. The rest of the live stock consisted chiefly of horses and mules, and of these the mules were by far the most important. They were bred not for shipment overseas but for use in Upper Peru (now Bolivia) where there had grown up a number of notable Spanish towns dependent on mining. Their great elevation—nearly half the existing towns of Bolivia lie at elevations exceeding 12,000 feet⁸⁹—made life hard not merely for man but also for his beasts. The mines were worked in a primitive manner, the towns associated with them were at elevations so great as to limit forage crops. When we consider the primitive mining organization of that time we can realize that a town like Potosí, at an elevation of 13,388 feet and with a population by 1650 of 160,000, must have required a horde of mules to perform the labor of handling the ore, crushing it, transporting the refined product, bringing in merchandise, and for the transportation of stagecoaches, and for use as riding beasts. Between the mining towns of the *altiplano* and the cities of the agricultural basins and valleys of the east like Cochabamba, Sucre and Tupiza, and of the coast valleys like Arequipa, there was a constant interchange of products, agricultural on the one hand and mineral on the other. Even today with the railroad to Cochabamba, La Paz, Oruro, and Potosí, streams of cargo mules continue to come in from the tributary towns and valleys; and llama trains likewise and two-wheeled carts, for the cost of carriage on the railroad limits transportation on it to vital necessities and luxuries—what we might call the overhead business of a region served by a principal town. Wherever there are low wages and abundant forage, transportation by pack mules in charge of a muleteer is cheaper than the railroad, and of course such transportation is still the main dependence for feeding the railroad.

In addition to the interchange of products over the highland trails there was also the transportation of minerals to the

⁸⁹ Isaiah Bowman: The Distribution of Population in Bolivia, *Bull. Geogr. Soc. of Philadelphia*, Vol. 7, 1909, pp. 74-93.

coast. For centuries this has laid upon both man and beast the heavy necessity of making such use of natural resources as they could. There were high mountains to cross, difficult streams to ford; at some seasons of the year there was drought so severe that water for stock was hard to find, at others the streams were in flood; and the extremes of weather encountered—the hailstorms and occasional snowstorms of the cordillera, the dust storms and burning salars of the high basins—all required the hardiest types of animals. The mule is not only well adapted to this service but is economical in that it has learned to forage at night for its food. It may be driven across the most inhospitable country in South America, browsing only on dried grass and bushes and perhaps a little green stuff carried with the cargo and some dried corn or preferably barley. It will live and work under these circumstances where a horse would die. Only the llama, the native beast of burden, can be compared to it for hardiness, and the llama is unable to carry heavy loads or to cover distances rapidly. After a severe journey the mule is rested and well fed for such time as it requires to regain its strength and to be in condition to undertake the next journey.

The source of the mule supply for the plateau was the Plata region. Between the two there was, on the one hand, a broken mountain country in places thinly inhabited, in places cold and barren; and, on the other, wide arid pampas, where good cattle pasture was found only at places widely separated and attained by crossing rivers, sometimes in flood, sometimes entirely dry. The times and the seasons of rain were reflected in a *periodic traffic*, and this naturally led to the development of the live-stock fairs at selected points, where buyer and seller could meet and conduct their business in short order and return home again.

The journey from Buenos Aires to Peru was accomplished in three stages, the first to Córdoba, where in the rainy season (November to March) water and pasture were to be had in abundance. There the troops were pastured for some months. In April they set out on the second stage of their journey. They were organized into troops of 1300 or 1400 head in charge



FIG. 56



FIG. 57

FIG. 56—A settlement in the montaña. The rain is here sufficient to produce crops without irrigation. Cloud and fog are common. Note the drapery of moss on the large tree at the left.

FIG. 57—The ranch house at Finca Santa Lucia, southwest of Rosario de Lerma, near the mouth of the Escoipe ravine.

of twenty men and seventy horses, and they aimed to reach Salta not later than the end of June so as to make the journey after the subsidence of the summer floods and before the period of drought. In the Salta basin the mules were pastured until fair time, which began early in February and lasted throughout March. Dealers from the pampas here disposed of as many as 60,000 mules alone, without including horses and cattle.

The Peruvian buyers made up their troops of mules, and the muleteers started on the mountain journey—the third and last stage. They knew the places of pasture on the mountain slopes and in the valleys and exported troops of 1700 to 1800 head in charge of two bands of horsemen, one to drive the mules and look after the camp arrangements, a second to prevent straying. Thus were the mules driven by slow stages to the markets of the plateau, Oruro, Corporaca, and Jauja. Oruro was the center of a mining district of Upper Peru, and it has retained its strategic relation to the mines down to the present. Corporaca is south of Cuzco and served a great central zone. Jauja is near the silver mines of Cerro de Pasco and the quicksilver of Huancavelica and on the royal road to Lima and the coast valleys. Ulloa says that 25,000 to 35,000 mules were pastured on the meadows of Canas, on the Tablada de Corporaca, and there sold in the great annual fair.⁹⁰

A change in the status of Buenos Aires in the latter half of the eighteenth century (compare pp. 107–108) effected a noteworthy decline in the traffic between the Plata provinces and Upper Peru, with corresponding effects on all the way stations along the great trail connecting these distant South Atlantic settlements with Lima on the Pacific slope. There was the decline in the output of silver from the Bolivian mines, and there was also the break in the economic dependence of Buenos Aires upon Peru, by reason of the fact that it was made a viceroyalty in 1776 and granted the privilege of free trade in 1778. Traffic over the land routes immediately diminished, the security of the route was no longer guaranteed by effective

⁹⁰ Antonio de Ulloa and Jorge Juan: *Relación histórica del viaje á la América Meridionale*, Madrid, 1748.



FIG. 58



FIG. 59

FIG. 58—The Escoipe ravine near the upper limit of the montaña, or woodland. The workmen are clearing the stream bed of large stones, an annual task. A part of the stream bed is a natural highway which requires but minor improvements.

FIG. 59—Pack train in the Escoipe ravine southwest of Rosario de Lerma. The mules are loaded with skins and hides in transport from the Calchaquí valley to the railway at Rosario.

outposts against the depredations of the Pampas and Chaco Indians, and these heavy handicaps were not removed entirely until the final subjugation of the Pampas Indians by General Roca in his famous campaign of 1878.



FIG. 60—The last outliers at the upper margin of the woodland that clothes the eastern flanks of the Andes west of Salta. Excellent pastures are interspersed with patches of woodland in this upper zone. The raising of sheep and goats is a major industry.

SALTA AS A ROUTE STATION

When the Wars of Liberation were ended Salta was left in a distressful state. The merchants had suffered through the suspension of trade, the campaigns themselves had fallen as a

heavy burden upon the frontier towns which had to bear the brunt of royalist attacks from the plateau, and the live-stock trade, the old source of supply and demand, the old relationships, the system of markets and fairs, had been badly disorganized. There were a few sugar estates, there was a local trade with neighboring valleys and basins; that was about all. By slow stages the former commerce was partly restored. The need of mules in Bolivia and Peru continued to be met by the herds upon the Argentine pampas. By the middle of the nineteenth century the copper mines of Chile were in a flourishing condition and made a demand upon Argentine live stock similar to that which the mines of Upper Peru had made in the two centuries before. In the latter half of the nineteenth century the nitrate fields of Chile began their period of large output, and the effect of these two great mineral developments on the Chilean side of the cordillera was felt in every town along the eastern front of the Andes in Argentina. Laborers migrated to the Chilean fields, trade sprang up on all the connecting trails, Chilean currency began to circulate freely on the eastern side of the mountains, and the economic condition of the border towns steadily improved. With the steady increase of population on the pampas of Argentina and in the coast towns there was a constantly increasing demand for all sorts of raw materials from every outlying place where commercial facilities were sufficient to attract the resources roundabout.

As the interior towns grew and travel between them and the coast ports increased through the extension of the railways, a taste for goods of foreign manufacture was acquired. Coca from Bolivia and maté from the Chaco were brought into northern Argentina in large quantities. A steady stream of wool, goat and kid skins, hides and leather went from the northwest provinces to Buenos Aires, and with the development of overseas trade in meat and meat products the attraction of the refrigerating plants of the Plata region was felt even in these remoter districts, so that today an item of increasing importance is the export of cattle to the plants along the Paraná and Plata.

The early colonial route to Bolivia and Peru via Jujuy and

the Humahuaca quebrada encountered competition from two main roads to the Pacific. These followed in part ancient trails by which the Indians of the Puna de Atacama and its high quebradas brought down their salt, goatskins, and woven fabrics to barter for the produce of the warmer valleys. Thence

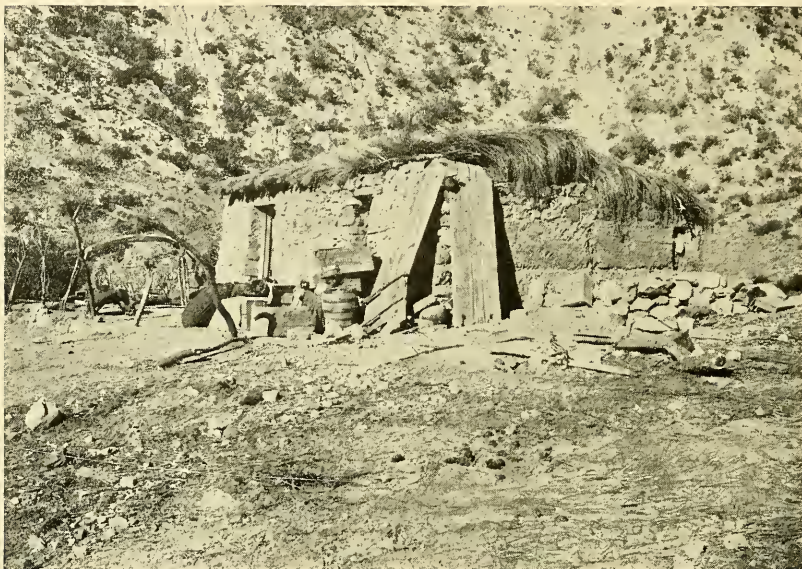


FIG. 61—Shepherd's stone hut at the crest of the Cuesta del Obispo above the limit of a favorable water supply and of the growth of cereals.

they crossed the Atacama Desert to Copiapó and Cobija (succeeded later by Antofagasta) respectively.⁹¹ The southern route passed through the Calchaquí valley, creating in Molinos a commercial station of importance, and thence, skirting the southern salars of the puna, entered Chile by way of the passes of San Francisco and Tres Cruces (Fig. 87, p. 259). The more northerly route passed through the ancient copper mining site of San Antonio de los Cobres, the stretch of "Despoblado" to the oasis of San Pedro de Atacama, and thence westward

⁹¹ For details of roads crossing the cordillera see Santiago Muñoz: *Jeografía descriptiva de las provincias de Atacama i Antofagasta*, Santiago de Chile, 1894, pp. 63 *et seq.*; Franz Kühn: *Descripción del camino desde Rosario de Lerma hasta Cachi*, *Bol. Inst. Geogr. Argentino*, Vol. 24, 1910, pp. 42-50.

across the Desert of Atacama to the port of Cobija. The routes were approximately the same length, 500 miles, requiring about twenty days for accomplishment. Both were arduous. Between Salta and the Pacific seaboard intervene the cold desert of the puna (Fig. 87) and the warm desert of the coast. Throughout the routes water, fodder, and fuel are only encountered at intervals. The reports of the first Spanish crossing of this region, Almagro's famous journey to Copiapó, vividly detail the perils of the road. Yet, despite the hardships, the routes were shorter and communication less interrupted and cheaper via the Pacific than the Atlantic. Page,⁹² of the United States Naval Expedition of 1859, investigated navigation on the Rio Salado (Santiago Province) and estimated that if practicable it would reduce the round trip from Salta to Rosario (distant 350 leagues by road) from eight or ten months to two months and the expenses by half. At the time of his investigation freight charges along this route amounted to \$2.00-\$2.50 per arroba (25 lbs.), while from Cobija on the western side of the broad and cold Andean uplift and the trying coastal desert they ranged from \$1.50 to \$2.00.

Salta has not yet been in touch with outside markets long enough to have more than begun the development of its agricultural and forestal resources. Its tributary streams of commerce are still of the casual, primitive sort that lacks both organization and development. The haciendas of the Lerma valley on the west where the railroad ends, the possibilities of the Calchaquí valley and of the plains country naturally tributary to the town are in a state of mere beginning. These valleys are adapted to a wide range of temperate, subtropical, and tropical products. In addition to them are the smaller tributary areas, the stock-raising establishments in the many regions that are now developed to a slight extent only. We may take by way of illustration the upper Calchaquí valley at the border of the Puna de Atacama (Fig. 66, p. 208).

⁹² T. J. Page: *La Plata, the Argentine Confederation, and Paraguay*, New York, 1859, p. 414.

CHAPTER X

THE SMALLER INTERMONT VALLEYS: THE LIVE-STOCK TRADE WITH BOLIVIA

THE CALCHAQUÍ VALLEY AND POMA

The physical setting of the village of Poma in the upper Calchaquí valley is not only picturesque but practical. It is a small settlement at an elevation of about 10,000 feet above the sea. On its west is the great mountain wall, surmounted by volcanoes, that forms the eastern border of the high and bleak Puna de Atacama. Its northern aspect includes the snowy peaks of Acay. On the east is a high and bold block of mountain country with smooth middle and upper slopes and deep-cut ravines at its foot (Fig. 65). The village is located on the western edge of the valley floor, and to the east of it and up and down valley are cultivated plots where barley is grown and irrigated alfalfa fields furnish forage for its live-stock industry.

From the whole northwest of Argentina there are sent annually to Bolivia at least 15,000 head of live stock, according to Guilberto Díaz, owner of the principal ranch or *finca*, La Poma, as it is called. They are driven from Catamarca, San Juan, Salta, and lesser border towns to summer in the alfalfa meadows at Poma, where a broad stretch of valley floor about five miles across and five miles up and down valley has been intensively irrigated and furnishes abundant pasture in well-kept alfalfa meadows. The 15,000 include in part 3000 mules, 4000 burros, 3000 cattle. They remain during December, January, and February and are then driven north into Bolivia. Apart from this industry and the cattle driving westward across the cordillera the town has no important outside business except the export of goatskins and salt. The manner in which one reaches the town serves to illustrate the difficulties attending the trade.



FIG. 62



FIG. 63

FIG. 62—Looking due east from a point near the crest of the Cuesta del Obispo and showing undissected portions of an old mountain range now cultivated nearly to its summit. In the background is a range in a still more advanced stage of erosion.

FIG. 63—Looking westward at the main front of the Eastern Cordillera from an elevation of 11,300 feet, with the Nevados de Cachi in the background and the deep depression of the Calchaquí valley in front of them. Photograph taken from the crest of the Cuesta del Obispo.

THE ROUTE TO POMA

From my field journal are the following notes on the region. At Rosario de Lerma, the railway terminal, I met my pack train, and soon after starting we crossed the dry stream bed of the Rio Manzano (Pl. 2, p. 192). We passed ranch houses and irrigated alfalfa fields with orchards. In the late afternoon we ascended the Escoipe ravine. We camped on the middle slopes where a fairly heavy growth of scrub occurs and from turns in the trail had a view out over the irrigated land at the south of the mountains. The water of a half-dozen mountain streams is diverted through more than a score of main irrigating channels that make the valley green with corn and alfalfa. Within the mountains the principal valleys and the gentler lower slopes are covered with grainfields, chiefly barley and wheat, up to the edge of the broken land and to the limits of cultivation. From this point the trail climbs into the higher and rougher country of the Cuesta del Obispo and neighboring ridges that lie between Rosario de Lerma and Poma. Beyond these the descent begins; but it is gentle, and after passing the small Sierra de Tintín and other lesser topographic elevations one comes into the broad and semiarid Calchaquí valley. In the southeastern corner of the Rosario de Lerma sheet (Pl. 2) may be seen the flatter slopes of the alluvium-covered floor and the pattern of the irrigated tracts. Here and there are bits of better-watered ground with pasture. But for the most part the dry and gravelly alluvium has only scattered bunch grass and cactus.

On reaching the irrigated portions of the Calchaquí valley there is spread out before one a charming view of mountain and valley floor. From Palermo up valley there are scattered corrals and ranch houses and patches of green that mark the exit of mountain streams which here rise in the zone of clouds at the edge of the Puna de Atacama and sweep down to the alluvial lands where they nourish the fields (Fig. 64). Both the main stream and its tributaries have cut their channels below the general level of the valley floor so that steep banks of earth run for long distances parallel to the stream. But



FIG. 64—The Nevado de Cachi on the western side of the Calchaquí valley. Hacienda Palermo lies in the middle distance. The mountains are snow-covered in part for most of the year. Below the snow is grassy vegetation down to the valley border, but the valley floor is dry except where irrigated.



FIG. 65—The Calchaquí valley at Poma showing the dry upper slopes of the valley covered with bunch grass (foreground), and the irrigated and partitioned valley floor. Note the stream channel near the right margin of the photograph coming down over the cultivated alluvial fan of the middle distance. Beyond the fan are the dark slopes of a mountain ravine which heads in the high country on the left where there are heavy winter snows. Looking east. See also Figure 66.

for this habit of the river its water would be far more useful to the people of the valley, because each stream must now be tapped far above a given settlement in order that water may be brought out at the terrace tops where arable land is found. Poma itself consists of a ranch, on which are a few huts surrounding the house of the owner, and directly up valley the village of two-score houses. From any vantage point in the valley one may see right to the head of it fifteen to twenty miles away where snow lies on the high peaks of Acay during the winter. On either side of the valley floor are the huts of the natives scattered at wide intervals, their flocks ranging over many acres of mountain side in search of pasture.

SUITABILITY FOR STOCK GRAZING

The site of Poma is the bed of a temporary lake, now partly dry land, partly swamp, where the hollows of the former lake floor have not yet been completely filled up or drained. The origin of the lake is found in geologically recent volcanic action. Four miles south of Poma are twin volcanoes (Fig. 66). When the flow first occurred the river was dammed up, and a lake several miles in extent was brought into existence. With the cutting down of the diverted stream into the rock at the edge of the lava flow at the western side of the valley the lake was drained. Thus it came about that an extensive area of flat land in the midst of mountains watered by many streams from the adjacent high cordillera has given rise to a settlement far removed from any large center of population. In an air line from Poma to Rosario de Lerma it is 50 miles, and the distance is almost doubled by trail.

The valley behind the lava dam is topographically well adapted to the control of live-stock feeding. Steep mountains on either hand prevent the mules from straying too widely. Barley and wheat are raised up to 11,000 feet, as we observed on June 16 in traveling across the Cuesta del Obispo; but this is in a situation well protected by deep valleys roundabout from the cold-air drainage that threatens the cereal crops in sites nearer the cold cordillera. At Poma alfalfa is the chief

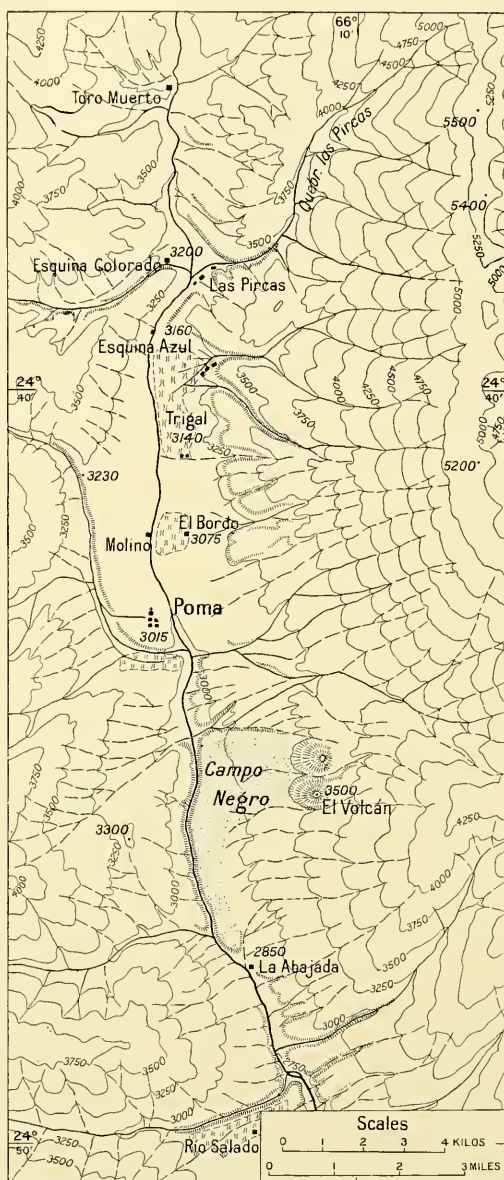


FIG. 66—The upper Calchaquí valley. Campo Negro is a volcanic flow that blocked the valley making a lake in the Poma district. When the outlet was cut down the lake bottom became a valley floor. The other shaded areas represent irrigated districts.

crop. It decorates the valley and makes it seem exceptionally attractive after one has journeyed over the lava flows and coarse piedmont of the intervening basins and mountains.

So fertile is the soil of the Calchaquí valley at Poma that alfalfa lasts for twenty-five years without resowing, whereas at Salta and Santa Fé it lasts but three years on account of the heat and drought. This means much less work in the higher valleys and a corresponding economy in the management of an estate. Yet the climate is sufficiently mild in winter to permit open grazing. The fields are therefore pastured the whole year round, and the grass is not cut for hay except for limited winter feeding. The work on a given ranch, or finca, as on that of La Poma, is chiefly to open ditches and clean them out each

year and prepare the soil of new alfalfa fields for sowing. From June to August it is too cold to irrigate the ground, for the water freezes during the night and interferes with the proper distribution; and, beside that, if it were allowed to freeze in the alfalfa meadows it would destroy them. Hence all up and down the valley the alfalfa is cut and stacked for winter feeding, and there is no irrigation except between the latter part of August or September and May or April. By the time the mules and burros arrive on their way to Bolivia, that is in the months of January and February, the pastures are in good condition.

The necessity of conserving water in the valley is very great, and it is traditional among the Indian population today that there has always been an immense amount of quarreling among the owners. Each landowner of the Calchaquí valley has the right to all the water that originates on his land, a privilege of considerable importance in a restricted valley where tributary streams have their sources at high elevations in a zone of more abundant rains. Each owner also has a right to participate in the use of the main stream that flows down valley through his district.⁹³

LANDOWNERSHIP

Outside the circle of influence of such a valley the Indians of the Puna occupy the soil without responsibility to a white owner. They pay neither rent to white owners nor taxes to the government. This is on account of their poverty and restricted resources. They are limited to the grazing of llamas, sheep, and goats in the least desirable lands and obtain the rest of their supplies by exchanging the products of their flocks with Indians farther down valley. The *arrenderos*, on the other hand, pay 50 cents a hectare (about $2\frac{1}{2}$ acres) in the form of a municipal tax, but they pay no national tax. The owner of the land must pay from \$2.40 to \$4.00 per valuation of \$1000 on each hectare.

⁹³ The water question in the northwestern valleys of Argentina is described and compared with more southerly conditions (cf. pp. 128-130) by Pierre Denis: *The Argentine Republic*, London, 1922, pp. 43-46.

There are only about 200 or 300 Indians in the Poma region at the present time. They act as muleteers for the pack trains and otherwise herd cattle, sheep, and goats and raise a few potatoes and the like.

There is no law compelling the Indians (called peons, i. e. workmen) to work on the fincas, or farms, as in Bolivia and parts of Peru. The use of the land is arranged when they come to rent it. Each finca is a cross section of the valley and is generally owned by whites or persons of mixed white and Indian blood. A part of each proprietor's holdings in the valley is cultivated under his personal direction, though the greater part is pasture land. What he does not superintend directly he rents to so-called arrenderos. A few white people are arrenderos, but for the most part the Indians are the renters of the land. They obtain their right to work it for a stipulated sum, and, as we have said, grazing rights are free. The topographic relation of arrenderos to hacendados is shown in Figure 67. The arrenderos cultivate barley, potatoes, and alfalfa at the mouths of the tributary valleys where there is ready access to the trails that connect them with neighboring ranches and settlements. The tributary ravines that enter the main valley on either side are so steep-sided and deep and so nearly barren in their mid-slopes as to constitute excellent natural boundaries between the different fincas, hence in the land titles the boundary is said to run from one quebrada or ravine to another and the estate to comprise all the land between.

For six or eight years before the World War the purchase of land in Argentina had been going on rapidly in sympathy with the rapid increase in the price of farm products. Everyone was trying to get land. In the Calchaquí valley the price of property advanced from three to five times its value a few years earlier, and a number of large ranch owners were able to sell the least productive parts of their holdings in fractions for prices that amounted to as much as the entire sum paid for the land five years before. Guilberto Díaz at Poma bought 63,000 hectares in 1903 for 83,000 pesos. In 1912 he sold 30,000 hectares, chiefly in the mountains, for 80,000 pesos.

Señor Díaz gave me some details about his farm which are worth recording here. Before 1912 it consisted of 63,000 hectares in all and extended from the summit of the mountains on the east to the edge of the cordillera that bounds the Puna on the west. Five hundred hectares were under cultivation in the valley. In 1913 he had 60 arrenderos upon his land and a total population of about 300. Each arrendero pays according to the size of his finca. For example those that control from

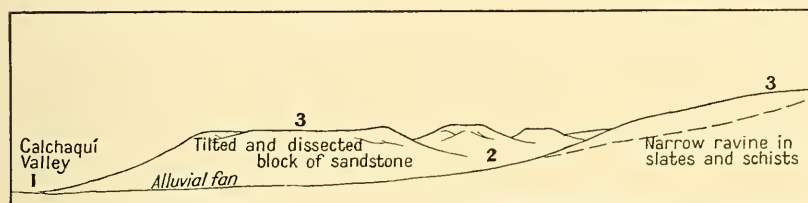


FIG. 67—The eastern border of the Calchaquí valley looking northward. To show use of the land. The numbers refer to sites as follows: 1, finca (main ranch or farm); 2, arrenderos (tenants); 3, pasture sites for flocks of arrenderos.

1 to 10 hectares pay 50 pesos a year. They work a month, more or less, upon the fields of the owner and for his benefit when it is convenient for them, and in return he pays them 15 or 20 pesos for their labor. Sometimes they dislike the work to which they are set or the conditions under which they are obliged to work, and they are free in such cases to move to another place where they imagine the circumstances may be more favorable.

The arrenderos move about a great deal, not only in this manner but as travelers and traders, while their families stay at home to occupy the hut and guard its belongings, to till the soil, and to shepherd the flocks. Some of them go even as far as the Yungas in eastern Bolivia. They drive mules to the Bolivian mines and return with coca. The cost of a 22-kilo package of coca on arriving in Argentina is 50 pesos and the duty on it $5\frac{1}{2}$ pesos. Upon their little fincas the arrenderos keep goats, sheep, cattle, mules, and burros, and the habitations are built upon little alluvial patches at the base of the

steep slopes. On several miles of valley side I counted six or seven such farms.

DISPOSITION AND LIFE OF VALLEY POPULATION

The huts of the arrenderos are scattered throughout the lower valley slopes. The last of them are generally located no higher than 10,800 to 10,900 feet. The highest hut I saw was at an elevation of 12,100 feet in the ravine of Peñas Blancas.



FIG. 68—The main street in Poma, Calchaquí valley.

It was a small stone hut thatched with grass and had a corral connected directly with it (Fig. 112). The thatch is made of *car-rizo*, clump grass somewhat like pampa grass; the long stems give it stability, and it is weighted down with stones. This hut was occupied in the months of January and February when the rains come⁹⁴ and the warmer weather. In June, at the time of our visit, it was unoccupied. At the mouths of many of the tributary valleys corrals are built, and sometimes stone fences are laid across constricted portions of the valleys from steep cliffs on one side to steep cliffs on the other to prevent the down-valley movement of the flocks. The shepherds or persons in their employ are in all cases the arrenderos of the valley

⁹⁴ Kühn (*Zeitschr. Gesell. für Erdkunde zu Berlin*, 1911, p. 149) gives the precipitation of the Calchaquí valley as 200–300 mm. for January, February, and March.

mouths. Grazing extends to 14,000 feet up the large tributaries, and on account of the up-and-down-valley winds the huts are placed not at the mouths of the smaller tributaries but to one side of them so as to escape the winds.

The porticos of the principal houses at Poma face east or south to avoid the heavy afternoon wind of winter and to get the shade of summer. The wind begins about 11 o'clock in the morning and becomes heavy about 1 P.M., blowing with



FIG. 69—The ranch house at Hacienda La Poma, showing the pack train about to start across the Puna de Atacama.

greatest velocity from then till 4 P.M. and often continuing into the night at gale strength. Houses that face east have the advantage of the early morning sun, and thus the temperature of courtyard and portico is a grateful change from the bitter cold of night to summer warmth.

Twice a year a priest comes from Cachi down the valley (Fig. 1) at his own convenience to attend to the needs of the inhabitants of Poma. He remains a fortnight, baptizing, marrying, holding services for those who have died in the interval since his last visit, and ministering to the spiritual needs of the settlement. The church is a small adobe structure, with a square bell tower, on the main street of the village. Like the houses of the residents the woodwork of the church is

largely from the native cactus (see Fig. 98), or cardón, with some imported parts from the distant woodland that clothes the eastern mountain slopes above Rosario de Lerma (Fig. 95).

The life of Poma in one aspect or another is repeated in many of the border valleys. Among these is Luracatao, a tributary valley of the Calchaquí. It sends some 300 head of cattle a month to Chile. They go in troops of 60 head, traveling about nine to twelve miles a day and going to markets even as far north as Iquique. The large-boned, large-hoofed beasts, shod for the journey, are of a type well fitted for such travel; but even they, especially during the winter, arrive in poor condition. It is estimated that they lose one hundred pounds on the road.⁹⁵

The Escoipe valley has products and a cattle business similar to the Calchaquí. At least a score of high mountain valleys are under development on the mountain border as way stations for cattle or as pastures for flocks and herds whose products are sent to Salta and eventually to Buenos Aires for overseas markets.

THE LIVE-STOCK TRADE WITH BOLIVIA

One might suppose that so isolated a community as Poma would have little value, and yet so important is the combination of water and good soil that every favorable spot between the puna and the plains has been discovered and developed. The chief business of Poma, as we have seen, is the grazing of live stock during the winter when the flocks and herds must be driven down from the surrounding high mountains to the more sheltered valley floor. The settlement is also important as a station in the live-stock trade with southern Bolivia. The difficulties of the way oblige the dealers to drive their cattle slowly and rest them frequently in favorable spots. Every year a stream of mules, asses, llamas, sheep, and cattle go north from the Poma valley over high passes to Bolivia where they are sold to the mines or to the railroads where construction is in progress, or are held for the great annual fair at Huari, Bolivia. At this celebrated fair there gather every

⁹⁵ E. A. Holmberg: *Viaje por la Gobernación de Los Andes*, Buenos Aires, 1900.

year an immense number of merchants from northern Argentina, Bolivia, and Peru. They trade in all manner of products of mine, forest, field, and garden. It is one of the principal bartering places of Hispanic America.

THE HUARI FAIR

Information concerning the great fair at Huari is not easy to obtain because the right to manage the fair is sold to the highest bidder and whatever records are kept are widely scattered, and I have no doubt practically all of them are soon lost. I had made many inquiries at different places throughout the Central Andes in the hope that I could piece together an accurate description of the fair. Quite by accident I met one of the concessionaires who had bought from the government the state and municipal duties in 1907 and had kept all information concerning the fair in a record book from which I copied the data that follow. His name is C. J. Bosman, and in 1913 he was the proprietor of the Hotel Atacama at Copiapó.

Huari is governed by the municipality of Challapata, a town on the railroad east of Lake Poopó on the high plateau, or *altiplano*, of western Bolivia (Fig. 1). At Challapata every year the municipal dues are put up at public auction and sold to the highest bidder. In 1907 the number of people who came to attend the fair from outside the town and district was estimated at 7000 to 8000. Before putting up a shop the outsider must pay a tax. If he does not take this precaution he is fined, and the fine goes to the *Rematador de los Impuestos*, or the person who obtains from the government the right to manage the fair.

All liquors that come in pay duties to the concessionaire, who controls their import, with the exception of alcohol and *chicha*, the latter a local native drink made, as a rule, from the fermented juice of corn. While the fair lasts for fourteen days, it passes its climax in three days. In 1907 it was held on April 24, and it is the custom to open it the day after Holy Week, or "Semana Santa." The concessionaire in 1907 employed five persons to collect dues and administer the trade.

He had at his disposal the police department of the town. In addition, the government sent twenty-five soldiers under the command of the sub-prefect to keep order. At night the place was patrolled by two hundred Indians in bodies of fifty each.

The following table gives further statistics, as copied from Mr. Bosman's record:

	<i>Number</i>	<i>Charge</i>
Horses brought to fair.....	43	30¢ each
Mules.....	2786	30¢ each
Bullocks, etc.....	1894	30¢ each
Donkeys.....	1767	30¢ each
Shops (only during fair).....	53	\$10 each
Tents.....	114	\$5 each
Hotels.....	2	\$50 each
Boarding houses.....	28	\$10 each
Women sitting outside anywhere selling food.....	97	\$5 each
Gambling tables.....	31	\$20 each
Roulette.....	1	\$500 each
Butchery.....	2	\$10 each
Bakeries.....	7	\$5 each
Canteens (saloon).....	67	\$20 each
General merchandise stores.....	1	\$50 each
Shops for coca.....	29	\$5 each
Alcohol (government supply).....	1	0 each

Anyone journeying through the Central Andes from north-western Argentina to Lake Titicaca westward to the Pacific at the present time could manage to see a great deal of the country from the railroad, but the conditions of rail transportation would conceal the background of the people who had made the country in decades and centuries past. To understand the structure of the life of the region today, one must know that the railroad is a very recent affair. Until it came—and the beginnings of the Andean railroads date back but little more than twenty-five years except near mines or on the coast of Chile—goods had to be brought in on mule back. As late as the years 1901 to 1906 C. J. Bosman took yearly trips from the coast, and his experiences illustrate the sort of trading that is still done all through those districts not served by the railway. He bought six strong Argentinian mules at Calama, which was then the end of the railroad in Chile, and with a cargo of general merchandise set out for the plateau country

to sell to all sorts of stores in Bolivia. He made the trip five times in succession in five years, taking nine months for the journey. He traveled about two thousand miles on mule back on each journey and about two hundred and fifty miles by stagecoach. Bolivia at that time had the reputation of having the largest consumption per head of conserved food of all countries in the world. He took wines, liquors, teas, flour, candles, and the like. In the best year he handled merchandise having a total value of £35,000. He went from Calama to Uyuni at the southern end of the Bolivian plateau, thence to Tupiza, Tarija, Camargo, Potosí, Sucre, Cochabamba, Santa Cruz de la Sierra, Villa Bella, back to Cochabamba, Oruro, La Paz. From Oruro to La Paz he traveled by coach, the mules being sent to Corocoro to wait for him. From La Paz he went to Corocoro by coach and to Sorata by pack train. At Sorata he sold his mules for use in the rubber country, and all merchandise that he could gather was likewise sent down the Tipuani trail for Mapiri on the Mapiri River, a tributary of the Beni. From Sorata he went to Guaqui at the eastern end of Lake Titicaca on mule back, the mules having been sold at Sorata on condition that they should take him to Guaqui. Thence he went to Puno, across Lake Titicaca by steamer, from Puno to Mollendo by rail, and at Mollendo he took the steamer to Caldera, thence by rail to his home in Copiapó.

George Earl Church, writing in 1877 and describing the cart roads of the high plateau of Bolivia and the absence of rail transportation, spoke of a country beyond the reach of a railway as being in a state of "territorial imprisonment." He gave⁹⁶ a "list of freights" from Cobija on the coast of Chile to Potosí and enumerated the difficulties and uncertainties both as to passage and cost owing to the irregular and deadly competition of mines, such, for example, as Caracoles, 40 miles inland from Cobija (compare p. 172). A similar list is given for the cost of unloading and transporting goods from Arica to Tacna, thence to Cochabamba and other plateau towns.

⁹⁶ G. E. Church: *The Route to Bolivia via the River Amazon: A Report to the Governments of Bolivia and Brazil*, London, 1877.

CHAPTER XI

THE CHACO COUNTRY AND THE CATTLE TRADE WITH THE NITRATE DESERT

In Colonel Roosevelt's "Through the Brazilian Wilderness" there is a most interesting description of the grasslands that border the middle and upper Paraguay and lie all about its headwater region and beyond. Once a practical cattleman, he was able to appraise the country as one of great future development. It consists of northward outliers or fringes of a broad belt of grassland a large unit of which forms the vast *Matto Grosso* of Brazil, while the other unit forms the *Gran Chaco* of southeastern Bolivia and adjoining parts of Argentina and Paraguay.

THE GRASSLANDS OF THE CHACO

These grasslands are quite different from the wide open pampas of Argentina, which are virtually treeless except for the imported poplar and eucalyptus, and different also from the llanos of Orinoco, partly because of the climatic conditions, partly because they are much more extensive, and partly also because they are much farther from the sea. So-called "gallery forests" along the banks of the streams are the rule; and in addition there are patches and clumps of woodland, and in places the soil is occupied by broader but limited tracts of forest. The distinctive physical qualities of this belt of grasslands have made their impression upon the life of the region; for example, owing to its remoteness, long expensive journeys by pack train or oxcart must be made to reach a river or a distant railway terminus. It is a true frontier region like our own West of an earlier day in some respects, unlike it in that the way of the pioneer leads northward toward ever more tropical conditions instead of lying along the same parallel of latitude. Labor is difficult to obtain. The plague of insects, the long distances between settlements, the uncertainties of a water supply combine to make difficult and sometimes hazardous the trade or even the mere livelihood of the hundreds of pioneer

communities that now lie scattered along the watercourses or about the rim of the grasslands.

Having to wait for a week at Salta while the mules were being prepared for the pack-train journey that I was to take across the Puna de Atacama, I employed the time in going to the end of the railroad at Embarcación to look into at least the border of the region and to learn what I could of the trade at this frontier town and of the conditions under which the trade was carried on. The railway descends from 1187 meters (3893 feet) at Salta, in a mountain basin, to 286 meters (938 feet) at Embarcación, on the piedmont plains. It was completed to the latter city in 1912, the first passenger train running in January of that year, though the line to Salta was built 35 years ago and to Jujuy 30 years ago. There have been two chief reasons why the railroad has been extended into the edge of the Chaco. First, there is the trade with the settlements at the foot of the Andes where the Chaco and the mountains meet, a trade that was at best feeble and carried on by pack train and oxcart over almost impassable tracts and that in itself would not have proved a sufficiently strong magnet. But oil was discovered in south-central Bolivia near Cuevo north of the boundary town of Yacuiba. The transportation of iron pipe and well-drilling machinery required the improvement of the track and the extension of railroad facilities. The total commerce from Embarcación north in 1913 was 12,000 tons a year. The distance to the Bolivian frontier is about 100 miles, and the cost of carriage is startlingly high. From Buenos Aires to Embarcación a carload of 30 tons costs \$500 to transport. The well tubing at Embarcación is said to cost 4 cents Argentine a pound. One section of 6-inch tubing weighs 300 pounds, and five of these make a cartload for six mules. From Embarcación to Santa Cruz de la Sierra transportation costs from \$7.00 to \$10.00 a kilo and to other places along the way a corresponding amount; thus to Yacuiba on the frontier, or the first 100 miles of the journey, it costs \$1.30, and the balance, of \$5.80 or more, is for the next 500 miles of the total distance of 600 miles. Mather, who visited the region in 1920, writes in the *Geographical Review*:

"In spite of the tropical location the climatic conditions seem entirely favorable to the settlement of the region [the foothill border of the plain] by white men. Its backwardness appears to be mainly a result of its remoteness from the established centers of civilization. This remoteness, however, cannot delay much longer the settlement of this land by energetic and ambitious pioneers. A preliminary survey for a railroad to run from Embarcación to Santa Cruz by way of Yacuiba, Villamontes, and Charagua has already been completed. The Bolivian government, however, is opposed to the construction of such a railroad until the completion of the Cochabamba-Santa Cruz Railroad, also *en proyecto*, because of the fear of increasing the already close co-ordination of eastern Bolivia with Argentina before the contacts of eastern Bolivia with western Bolivia are perfected. Both these railroad projects, however, will probably be consummated within ten or fifteen years."⁹⁷

At Embarcación I interviewed the agent of the principal commercial company and obtained from him invaluable information; and while there I also met for the first time Baron Erland Nordenskiöld, who, with his wife, was just starting out on a third journey into the Chaco to make a detailed study of the Indians and their culture. He had also traveled along the border between forest and grassland on the Bolivian-Argentinian frontier in 1901-1902.⁹⁸

A ROUTE ACROSS THE CHACO

I was fortunate enough to have as a traveling companion on the way to Embarcación a railway engineer who had crossed

⁹⁷ K. F. Mather: Along the Andean Front in Southeastern Bolivia, *Geogr. Rev.*, Vol. 12, 1922, pp. 358-374; reference on p. 374. Compare the situation as regards Transandean lines between Chile and Argentina, p. 97.

⁹⁸ Baron Nordenskiöld, in his article "Travels on the Boundaries of Bolivia and Argentina" (*Geogr. Journ.*, Vol. 21, 1903, pp. 510-525), gives an account of his first journey in South America, where altogether he has spent six years in archeological and ethnographical exploration. On the Chaco region he has written "Indianerleben (El Gran Chaco)" (Leipzig, 1912), and Chaco tribes are dealt with in the first two volumes of his "Comparative Ethnographical Studies" (An Ethno-geographical Analysis of the Material Culture of Two Indian Tribes in the Gran Chaco, Göteborg, 1918; The Changes in the Material Culture of Two Indian Tribes under the Influence of New Surroundings, Göteborg, 1920).

the Chaco repeatedly and who had a file of notes and memoranda which he kindly placed at my disposal. Only the fact that he asked me not to give his name prevents my giving him the credit that is his due. I have condensed the material he gave me to the following brief description, which serves to picture the country that comprises the grasslands of the Chaco.

Starting at Villa Concepción on the Paraguay River, on the Tropic of Capricorn, and going west, one crosses the Pilcomayo River and the Bermejo, just south of Embarcación. I know of no published description of just this route, though we have the excellent general account of the missionary W. Barbrooke Grubb,⁹⁹ who has described the section of the Chaco between the 23rd and 24th parallels. For thirty leagues (a league is the distance that a mule will travel in about an hour—it is about three miles and is not to be thought of as an exactly measured distance in country like this) west of Villa Concepción the land is almost exclusively *palma*, that is low-lying *compo*, or grass covered country, liable to be inundated with water from the overflow of neighboring *esteros*, or swampy tracts, and dotted with palm groves. For the next fifteen leagues farther west the country is more broken, with algarrobo trees and small *montes*, or forest—woodland we should call it—containing quebracho, and also with long *esteros*, some of them appearing to be abandoned river courses. Toward the end of the swampy stretches the palms gradually diminish and finally disappear, the quebracho becoming more plentiful. Here the land rises appreciably, the large *esteros* vanish, the soil is sandier, and grasses unlike the swamp grasses farther east begin to appear. Then for five leagues farther the *montes* become more numerous, with small quebracho tracts. The water becomes scarcer, lying in hollows which soon dry up. For the next six leagues the country is

⁹⁹ W. B. Grubb: *An Unknown People in an Unknown Land*, Philadelphia and London, 1911; and also *idem*: *A Church in the Wilds*, New York, 1914. In appendixes to the former Mr. Grubb quotes from Professor J. Graham Kerr's account of the Chaco and its exploration published in the *Scottish Geogr. Mag.*, Vol. 8, 1892. "Chaco exploration is a sad record in many respects, showing an enormous expenditure of human life, with but very slight resulting gain to our knowledge." To the list of attempted penetrations might be added that of Thouar in 1886-1887, which got more than half way across from the Pilcomayo to the Paraguay in about latitude 22° 50'.

campo, or grassy plains, so open that in places one may have uninterrupted view to the horizon both north and south. Dead, burnt quebracho trees are numerous, but otherwise there is little in the way of woods. Apart from one small hole, at which the Indians have a well in the dry season, water is entirely absent in this stretch. Toward the end of the six leagues in question is a broken monte, finally opening up to large campo, closed by monte on the north and on the south by the Riacho Monte Lindo, which flows between banks four meters high with very little water and that brackish.

For the next nine leagues the banks of the Monte Lindo retain their height, but the water is only a few inches deep and continues brackish at first, then becomes sweet as afterward the bed is full of grass, showing that water is only temporary. My informant's party followed Indian tracks, proceeding as directly westward as they could—there were no trails—by which they ultimately reached the head of a stream two leagues farther, where there was a small pool of excellent water said to be constantly used by the Indians, who are very careful in their descriptions of so important a feature as their water supply. At this point, 67 leagues from Villa Concepción, is an Indian *toldo* which is quite old, and the number of people in it would exhaust the water in a week if there were not a constant source of supply. Along the stream the country is hilly, but the hills are not more than 100 to 150 feet in height. On either bank of the river is an open space 200 to 300 meters wide. The soil is sandy and porous, and pasture is intermixed with leguminous plants. The settlement is on a highway for the Indians, and on it they invariably carry gourds filled with water. At the same time, the large amount of fresh-appearing vegetation would indicate water at a slight depth below the surface.

For the next seven leagues the land falls slightly, the montes are not so rich in valuable timber, and water is quite absent. At two villages in this stretch Indian settlements were encountered where the water was drawn from pools in the heart of montes near the village—an unusual situation for the pools though the water was permanent; and about one of the pools

were growing plants, somewhat like water lilies, and grasses, while a short distance away the trees looked parched and dry. At one of the villages there were about forty Indians, one or two horses, and a small flock of goats and sheep. The surface of the water pool upon which this settlement depended was not more than 12 meters square and shallow; but the village was old, and the spring was the only source of water. It was not a bubbling spring, such as one will find in the mountains or in favorable situations where there is a descent from higher ground, but merely a pool. In these montes there are water-holding plants particularly useful to man and beast in the eastern Chaco.

Farther on, or more than 200 miles in a straight line west of Villa Concepción, the country continues dry, and palms appear plentifully, indicating a lower level of the land. In no other part of the Chaco do springs occur, at least in the knowledge of my informant, who believes that the line of springs is due to uplift and erosion and thus exposure at the surface of a water-bearing stratum. Under these circumstances no intensive agriculture and no intensive use of the pasture land of the interior of the Chaco can be expected until well borings are made that bring to the surface the abundant water apparently existing underground. The water must be distributed in a manner that improves on nature before stock farms can be developed and cattle driven, as they must be for many years, to the river or the railway.

THE INDIAN POPULATION IN RELATION TO LABOR

The interior of the Chaco is not yet a safe place either for agriculture or for stock raising. Parts of it are inhabited by the Matacos and Tobas Indians, the former occupying approximately the upper courses of the Pilcomayo and Bermejo and the latter the middle and lower courses. The Tobas long had one of the worst reputations of all Indian groups in South America. Matacos, closely related to the Tobas, also made raiding expeditions out of the Chaco upon the pack trains and oxcarts that went up from Buenos Aires to Tucumán,

Salta, and Jujuy in the colonial period and indeed down to the middle of the last century. Along the main line of travel there was little danger of molestation from the Indians; but toward the north, where the trail ran nearest the Chaco country, the Indians were held in check only by force. At Salta and other places near or on the mountain border, fortified places were built. The fort of Cobos, a few leagues from Salta, was an outpost against the Chaco Indians, its garrison being supported by excise fees on each head of mule leaving the town.

According to Boman, during the sixteenth, seventeenth, and eighteenth centuries the Tobas occupied the forests of the San Francisco valley, which runs northeast of Salta to join the Bermejo below Orán. The Tobas were then nomadic and were the principal tribe of the Chaco in contact with the Spanish. At the end of the eighteenth century the Matacos invaded the region. The Tobas near the mountains were displaced and retired toward the interior of the Chaco. The Matacos are still today masters of the forest environment in the upper Bermejo.¹⁰⁰

The labor requirements of the sugar estates, the attractions of the merchandise of the white man, and particularly his control of the brandy supply, have conspired to weaken the Matacos, to diminish their numbers, and to bring them into peaceful pursuits. The Chaqueños, or ranchmen and merchants who have gone to the Chaco settlements for trade, the purchase of cattle, and the opening up of estates, now furnish the outposts in which labor is recruited for the plantations of northern Argentina. Expeditions still go into the Chaco to obtain labor. They visit the most isolated communities for the purpose of enticing laborers through the promise or the gift of brandy, tobacco, implements, and cotton textiles. But it is hazardous business. Ten out of a group of fifteen who went in on such a mission in 1913 were killed. An Indian who comes in to the sugar estates for work is called *peon de campo* and gets \$45 Argentine a month, or \$15 to \$20 in our money. Meat and rice is almost his entire diet, while both there and at

¹⁰⁰Éric Boman: *Antiquités de la région andine de la République Argentine et du Désert d'Atacama*, 2 vols., Paris, 1908; reference in Vol. 1, p. 78.

home he consumes the prevailing drink, *maté*. The plant is called *yerba* in the field and *maté* only when it is prepared for steeping. It is supposed to prevent scurvy among the meat-eating Argentinians of the Chaco.

The laborers are required principally on the sugar estates, a line of which has been developed along the railway between Embarcación and Güemes. Some forty years or so ago the first of these estates were organized, when everything that was brought thither, from supplies to heavy machinery, had to be transported by oxcart from the end of the railway at Tucumán. When the railway was extended to Güemes this town became the base, and later Perico. It was only about twelve years ago that the railway actually passed the doors of the estates, so to speak. With the coming of the railway new companies have sprung up that have developed the neighboring lands irrigable from the mountain streams, for the line of the railway is near the line of break between mountains and plains. The belt of sugar land is capable of early and great development northward as far as there is available water and yet an absence of dense forest. Santa Cruz is on the southern edge of a wet belt that extends northward with increasing rainfall until it merges into the zone of dense jungle and forest that embraces the eastern Andean mountain slopes and the Amazonian plain. From the Rio Grande at Santa Cruz southward to Yacuiba is a belt of relatively dry country with irrigation possible only in a narrow zone at the base of the mountain, and the adjacent plain is grass covered. From Yacuiba southward to Embarcación there extends a wetter zone. Still farther south, at Tucumán, irrigation is the rule, and the Chaco forest climbs up the hill slopes and appears as a belt of dense green between the cold arid belt above and the hot arid belt below (Fig. 86, p. 253).

The sugar estates, even as far south as Córdoba, employ a great deal of Indian labor, and this is the source of the labor expeditions into the Chaco for the purpose of obtaining Indian peons. I talked with the captain of one of these parties who is accustomed to take a dozen or more leading laborers from the sugar estates and go in with presents to distribute to the

Indians. He travels right across the Chaco to the Pilcomayo and all through the Bermejo country. As far as possible, the Bolivian government keeps a strict watch in each of the principal valleys to prevent the Chaco Indians from coming across the frontier into Argentina, for it wishes to keep its labor supply at home. While this is not a very effective means of stopping the drain upon its Indian population, it at least prevents any wholesale movement of the Indians; such as come must use the roundabout trails in the daytime or sneak across the boundary at night. They remain on the sugar estates for what they call a cane season, of several months to half a year, and then go back to their homes. Though their rate of pay is specified, they are actually paid in merchandise. Formerly they were given guns and ammunition but not now for the government prohibits the sale of firearms. They are supplied with knives, tobacco, shirts, trousers, brandy, and a horse apiece. They are good workmen after their fashion.

At home the Matacos live in *tolderías*, or villages, of a few to forty families. In the interior of the Chaco country the *tolderías* are larger than those on the frontier, but whenever they are near a white settlement the whites prevent their growth to great size for fear of an attack. The huts of the Indians are of bamboo and grass; they live in them only so long as they stay in a given place, but they travel about a good deal between growing seasons, settling in likely spots that take their fancy. At one of their settlements there will be a small patch of corn, generally near a water hole or spring, and otherwise they depend upon the sale of their cattle for food. They also have a few native vegetables. Almost every *toldería* has at least one person who speaks Spanish. They make a strong drink from the bean of the algarrobo and as they obtain the most effective action from this drink only when they chew tobacco, they appreciate a present of tobacco more than anything else. If a white man looking for labor gives them presents other than tobacco they are not always on hand to return value in labor; but if the present is tobacco they consider its acceptance as a contract for work. In each tribe the chief desires horses and especially a canvas tent in place of a hut.

From labor gatherers, missionaries, and railway engineers of different nationalities whom I interviewed, both here and elsewhere in Argentina, and who have had first-hand experience in cattle driving, cattle purchase, and the gathering of laborers, I have obtained an average estimate of fifty or sixty thousand Indians as the population of the whole of the Chaco from the Corumbá-Santa Cruz line southward to the Bermejo. Even if we multiply this by three we have a very limited population and one that will have to be conserved and strengthened in order to make possible the development of either the Chaco or its borderlands. It is of the utmost importance that the governments concerned and also the contractors for the sugar estates and ranches should understand the labor problem clearly. Imported labor cannot be depended upon until settlement is more or less continuous and the conditions of life far easier than they are today. It is the native laborer rather than the immigrant that must do the rough work. To demoralize the native Indian's social life, to destroy his energy with brandy, to take his lands without offering him a certain amount of fostering care, is to bring about his end and to check development along the whole of this important frontier.

THE BERMEJO REGION

On the way back from Embarcación I was particularly interested in the Bermejo River and at the crossing noticed rafts in process of construction for the taking of merchandise down river at times of high water to towns on the river bank. These are small settlements scattered here and there, and, according to the experienced merchants whom I saw, their supplies come almost wholly in this way. The men who take the rafts downstream sell the lumber at the settlements and come back overland. None of these towns exceed fifteen hundred inhabitants in size. At the mouth of the Bermejo, where it runs into the Paraguay, is Puerto Bermejo.

Small river steamers go up the Bermejo about 300 miles to trade with the settlements and towns. Twenty-ton steamers go up 250 miles, as far as Juntas, where the Teuco and the old

Bermejo join. Larger boats are apt to be caught by falling water. A sixty-ton steamboat is now lying wrecked at Rivadavia on the old Bermejo, having been caught thus. The old channel formerly carried most of the water, and though it was narrow it could be navigated. But the river overflowed its banks, forming a new channel; and the whole of the current is now carried by the new channel, which is called the New Bermejo or Teuco. At the railroad crossing the river bed is half a mile wide, but the river at the time I saw it was much narrower, occupying only one quarter of the width of its bed so that broad yellow and white patches of gravel and sand lay in sheets on either side of the curves, making a natural pathway down through the forest which grows in thick stands on either bank. Where I saw the forest it was quite variable in character, now consisting of trees whose trunks were forty to fifty feet in height and with even stands of one or two types of trees, again consisting of tall and short trees mixed with or without undergrowth. It grows densest in the low places and along the river banks and becomes thinner, with grasses appearing here and there, as one goes toward slight elevations or comes into the gravelly zone nearer the mountains, where the ground water lies at a lower level.

Such is the frontier region in which Argentina is now extending her important sugar belt and from which she draws an increasing number of cattle for the heavy demands of her own market and that of her neighbor, Chile.

EMBARCACIÓN AS A CATTLE STATION

At the village of Embarcación one sees long lines of freight cars loaded with bellowing cattle that make the place noisy day and night. They are long-horned stock from the Chaco. Some of them are driven for great distances, and the first stage of their journey is ended at the railway yards at Embarcación. They are not fed on alfalfa or bred for fine points. They are strong, large-boned beasts raised in the scrub and coarse pastures of the Gran Chaco, accustomed to travel long distances, to do without water for a day or two at a time, and to



FIG. 70



FIG. 71

FIG. 70—The gaucho of the Gran Chaco. The huge leather flaps hung over the saddle in front of the rider are for protection against the thorny scrub that forms a part of the Gran Chaco. They are called *guardamontes*.

FIG. 71—Long-horned cattle from the Gran Chaco assembled at Embarcación for shipment to Salta. Herds of these cattle are driven westward across the Andes into the Desert of Atacama.

stand the sun and the rain. They are thus naturally fitted for the hazards of an overland journey through difficult country.

During the time that I spent at Embarcación a number of troops of cattle arrived at the place. The photograph (Fig. 70) shows the type of cowboy, or *gaucho*, engaged in the cattle business. The curious broad flaps on either side of the saddle are the *guardamontes* which the gaucho wears as a protection. It is made of thick cowhide and is stiff and tough. In addition to it he wears a *colete*, made of soft hide, very flexible and agreeable to the touch, which is carried most of the time folded across his saddle. When he is out in the scrub chasing cattle the colete is thrown over head, shoulders, and back, and protected by this and the guardamontes in front of him on the saddle he can gallop along without fear of being scratched by the thorny scrub through which he must ride in order to round up the cattle. At night he sleeps on the guardamontes and covers himself with the colete. He eats only charqui (jerked beef) and rice, with a little corn. The group that I saw consisted of about ten boys and a man. The company had received their pay and were setting off in a most light-hearted and casual manner upon their long journey of 250 miles on the home trail to the Pilcomayo, whence they had come. They were Indian and Spanish half-breeds or quarter-breeds. Their pay was about 40 pesos a month.

The cattle are driven in to the railroad station from February to August. After that it is too dry for the business, for there is little grass to keep them in condition and water is too scarce, the watering places being too far apart. A drove of several hundred is in charge of five or ten mounted boys and men. The Chaco cattle fetch 75 or 80 pesos apiece at Embarcación, and it costs 4 pesos a head to ship them to Salta. They are sold to mountain drivers at about 115 pesos apiece.

STAGES IN THE DRIVING OF CATTLE TO THE NITRATE FIELDS

After being fattened in the cornfields and alfalfa meadows of Salta the cattle are gathered in troops of 50 to 100 each and under the care of drovers are taken first over the lower ranges

of the Pre-Cordillera. Some difficult going is experienced on the gravelly cactus-dotted alluvial plains and basin floors that lie between Salta and the eastern mountain wall of the lofty Puna de Atacama in this the third stage of their long journey. The trails however are selected so as to make the best use of such water and grass as the region affords. They strike the irrigated tracts in the valleys along the eastern border of the mountains where the cattle may be rested and turned into fresh pastures to be well fed before the fourth stage of the journey. In these high valleys the cattle also become somewhat accustomed to the altitude and the cold, for the climate is here temperate instead of subtropical as in the Chaco from which they have come.

Once prepared for the journey, they then enter the fourth stage, that of climbing the eastern mountain wall and crossing the Puna de Atacama. It seems at first an incredible feat that they are required to perform. The trails are stony and steep, and at the end of two or three days at most the droves of cattle find themselves upon the bleak, wind-swept puna where only the coarsest grasses and widely scattered watering places may be found. Finely bred stock would perish at once; but these hardy beasts are able to go two or three days without water, as they must in the most difficult sections of the puna. They travel only about fifteen miles a day, lumbering along in heavy fashion, bellowing now and then, straying whenever possible, yet urged forward relentlessly by the mounted gauchos. An occasional one becomes sick and is left behind when it can no longer be goaded on. Once abandoned it perishes. Almost every mile of the trail is marked by skeletons picked clean by the condors.

The cattlemen are Indians or half-breeds from the Salta region or the bordering valleys. They know all the trails and watering places, and they know what the cattle can stand. Their fare consists of charqui *chuiño* (dried potatoes), rice, and a few vegetables for soup. They carry no tents, but sleep on the saddle blankets of the mules, of which they take along a few as riding and baggage animals. They wear ponchos as a protection from the wind; and, skillful as they are, they find diffi-

culty in the worst places in keeping the cattle going. This is chiefly because of the wind. In the Gran Chaco, whence the cattle have come, the southeast wind prevails. It is a soft, warm wind, dry or wet according to the season, and affects the cattle but little, for they do not graze upon wide open plains but upon patches of campo scattered here and there among woodland or forest tracts. On the Puna de Atacama, however, the northwest wind prevails. Though the mornings are calm, the wind rises to gale strength in the late forenoon and by mid-afternoon is blowing with great violence, carrying sand and dust in considerable volume and weakening man and beast by its great force and low temperature. At times it blows all day at freezing or just a little above freezing temperatures. When it comes laden with snow or dust it is called *viento blanco* and envelops the herds of cattle and the horsemen and makes going exceedingly difficult. When it blows with greatest violence the cattle tend to break and run, seeking shelter one by one or in groups under the lee of large rocks or ridges or in tributary valleys off the main trail. To keep the cattle together and not to lose ground by having them run before the wind is often a difficult task, though it becomes less difficult as the western border of the mountains is reached, for the beasts are then so tired and enfeebled that they are glad to lie down at every opportunity. Thus they arrive at the western crest of the cordillera and begin the long descent toward the desert settlements, particularly that of San Pedro de Atacama.

It takes thirteen to fourteen days for cattle to be driven from Salta to San Pedro de Atacama. They wait at San Pedro one or two days, according to the need for beef at the nitrate establishments, as well as their own condition, which depends largely upon the weather they have experienced in crossing the Puna. The days of waiting are called "la tablada." In this time the cattle are fed liberally, and if any of them are ailing or footsore they receive the attention of a veterinary. From San Pedro it takes three days to drive them to the nitrate establishments, and the men return in two days more, receiving 45 pesos Chilean for the five days' work. On the return they rest from three days to a week at San Pedro or work in the fields



FIG. 72



FIG. 73

FIG. 72—A drove of cattle on the trail across the Puna de Atacama, near the pass in the main chain of the Cordillera de los Andes above Socaire (southeast of San Pedro de Atacama).

FIG. 73—Chaco cattle on the broad cattle trail near the edge of the Salar de Atacama *en route* to the alfalfa meadows of San Pedro de Atacama and the nitrate desert farther north. They have just crossed the high cordillera.

there, where they are paid 2 pesos apiece for feeding the beasts, digging out the irrigating canals, etc. If there is snow in the mountains they may remain longer. The men carry some alfalfa and dry barley in small quantities with their mules, and at Soncor they have to pay for the feed of their horses, which is one reason why that settlement has been long maintained.

DETAILS OF ROUTES

Señor Alvarez, who is one of the chief men in the cattle business at San Pedro, has furnished me with a schedule of the five principal cattle routes across the Puna as follows, and the points he gives are all indicated upon Bertrand's map of 1884 entitled "Mapa de las Cordilleras en el Desierto de Atacama y regiones adyacentes:"¹⁰¹

- I. From Salta via Quebrada del Toro, Gólgota, and Cebada (where there is pasture), Táctil (not Tastil as usually written), Cuevas, Chorrillos, Cauchari, Catua, Guaitiquina, Puntas Negras, Aguas Calientes, Lejías, Pajonal, Soncor, Aguas Blancas, Tambillo, and San Pedro.
- II. From Catua, Losló, Chamaca, Hécar (pasture here), Toconao or Aguas Blancas to San Pedro. Few cattle go over this route.
- III. Via Incahuasi (from Rincón) to Socaire (where there is a little pasture and alfalfa for sale), Quetena, and Carvajal (where there is pasture and water) to San Pedro.
- IV. From Jujuy to San Pedro. This is similar in character to Route I.
- V. From Jujuy to La Quiaca to Uyuni—thence by train to Antofagasta. This route is used only when the puna and the sierra are closed with snow.

In 1912 an experiment was made by Abaroa Brothers and A. Cerruti who sent cattle from Salta up to Catua or San Antonio de los Cobres. They were driven north to Quetena and thence

¹⁰¹ Alejandro Bertrand: Memoria sobre la exploración á las cordilleras del Desierto de Atacama efectuada en los meses de enero á abril de 1884, *Anuario Hidrogr. de la Marine de Chile*, Vol. 10, 1885, pp. 1-299 (map scale 1:1,000,000).

westward across the Maritime Cordillera to Chiuchiu and Calama; but the journey required eighteen to twenty days, and of the 60 cattle that started all but 28 were lost.

The fame that San Pedro has long enjoyed and the facilities it has for accommodating transient herds and droves attract the stockmen of Catamarca, La Rioja, San Luis, and Córdoba. For years they have sent droves of mules to be sold in the nitrate oficinas of the coastal desert farther north, but if they cannot sell them at a set price they turn northeast at Chiuchiu, east of Calama, and go up over the Maritime Cordillera to the great annual fair at Huari. The completion of the Antofagasta railroad has greatly disturbed this traffic. In place of mule transport there is now railroad transport, and the completion of the railroad itself liberated a great number of mules from the work of construction. Where 200 to 300 formerly went up to Huari there are now sent only about 100 or 150. They are driven across the cordillera principally in December, January, and February. They come in from the pampas to Catamarca, where they winter and get accustomed to the altitudes and are sent to San Pedro de Atacama by way of Antofagasta de la Sierra (Fig. 1).

CHAPTER XII

SAN PEDRO DE ATACAMA

Upon the western side of the Puna de Atacama, where the main chain of the cordillera surmounts it, is a line of settlements of which the first (from the north) is San Pedro de Atacama. With elevation of 8000 feet it is neither a high plateau town like San Cristobal de L pez (14,300 feet) nor a desert valley town like Copiap  (3000 feet) or Quillagua (2000 feet). Its site is so elevated that snow has been known to fall; yet the daytime temperatures are of the high desert type. It lies in a desert basin midway between the cold puna and the desert pampa. We have already mentioned the town in the preceding chapter in connection with the cattle business across the cordillera.

COMPARISON WITH OTHER BORDER SETTLEMENTS

San Pedro is the counterpart of Salta on the east, for it represents a focus of trade between the mountains on the one hand and the desert and the Pacific coast on the other, just as Salta and similar towns on the eastern side of the Andes are a focus of trade for the mountain valleys and adjacent plains. So far as the mountain trade is concerned, Salta acts as a collecting center for shipment to the western side of the mountains and to Buenos Aires, just as San Pedro de Atacama acts as a distributing center for cattle driven to nitrate establishments and settlements on the railway and to scattered mines.

In the case of San Pedro there is a degree of isolation which Salta does not have, for Salta has the railway and its life is much more vigorous and active. Salta lies upon the eastern, better-watered slope of the Andes rather than upon the dry, desertic western slope and basin country. Yet both towns have a certain similarity in history and in pre-railway life, and between them is similarity of ideas and businesses associated with life upon the frontier. Both are old settlements, dating back to the earliest colonial period. Both have a high propor-

tion of white residents born outside the district. Each has been the center of a certain amount of revolutionary ferment and the refuge of those who sought to escape from persecution by officials of a rival administration. Men come and go for political reasons in such situations in a manner to which we are not at all accustomed in this country. One sees the same thing



FIG. 74—Conde Duque, the principal settlement of the many that go under the collective name of San Pedro de Atacama. The view is across the valley with the main chain of the Andes in the background.

illustrated in many places in South America on opposite sides of a boundary line. A politician in difficulty in Peru or Bolivia may flee to San Pedro de Atacama, as those in political difficulty in Chile may flee to Salta on the other side of the mountains and in the territory of another sovereignty. At Puno and Guaqui at the opposite ends of Lake Titicaca, the one in Peru, the other in Bolivia, one will generally find little groups of political refugees who find it healthier for the time being to live in the territory of a neighboring state.

Because of its remote situation (it is still two days' journey from the railway) San Pedro has felt but little the effects of the general economic change which the railway has brought about elsewhere and which produced so revolutionary an effect in the life of Calama to the northwest and of Salta to the east. Its

credit system, its modes of transport, its community life, the way in which the land is utilized, the coming and going of the nomadic mountain shepherds, relations with tributary oases scattered in still more remote and isolated valleys up and down the western flank of the cordillera—all these give it a distinctive quality, and yet at the same time it serves as an example of the mode of organization and of the functioning of a distant desert town tied equally to the great wastes of highland Atacama and the lofty mountains and to the distant settlements beyond them.

Just as Copiapó serves to illustrate the life of larger communities based on irrigation but dependent also upon mines and railway, so San Pedro illustrates the structure of the smaller communities distant from the railway and resting their economic life upon the old and primitive means on which they have depended ever since their foundation centuries ago.

The dependence of the shepherds upon the high pasture along the western flank of the Andes and also the local pastures on the eastern slopes and basins of the main chain that forms the international boundary makes it difficult to administer a customs service precisely upon the boundary line, for the site is both cold and inaccessible. The shepherds pay no attention to the boundary in fact, and both Argentinian and Chilean slopes of the Western Cordillera are tributary to San Pedro. The customhouse is not located in the settlements at the base of the mountains but is near Tambillo, where the trails from the mountains converge toward San Pedro. The duty upon Argentine sheep driven across the international boundary into Chile is 4 pesos Chilean per sheep and 40 or 50 pesos per 100 pounds of wool.

ECONOMIC LIFE OF THE OASIS

On account of the dependence of San Pedro upon the cattle trade, the proposed railway across the mountains by way of the Guaitiquina gorge meets with disfavor here, for if it reached the coast by running south of the salar it would divert to another route the cattle trade, now the chief transport business of the town and the chief support of the alfalfa industry.



FIG. 75



FIG. 76

FIG. 75—Oasis of Soncor, western border of the Maritime Cordillera, Chile, where a small mountain stream terminates near the edge of the Desert of Atacama.

FIG. 76—The Chilean customhouse, not on the crest of the Western Cordillera where runs the boundary between Chile and Peru, nor yet at the first line of settlements at the foot of the mountains, but at the northeastern margin of the Salar de Atacama where the mountain trails converge before entering San Pedro de Atacama.

Alfalfa is sold chiefly to the cattle drivers that pass through, immense quantities of it being stacked up at convenient points near a water supply, with stone or mud fences about to keep the droves within bounds. Fruit is produced in large quantities and sold to the nitrate establishments on the distant pampa toward the west. Pears, apples, grapes, figs, quinces—these are the chief products, and they constitute the principal fruit crop of Toconao as well (Fig. 1). The latter town is a day's journey, or 25 miles, from San Pedro and is celebrated not only for its fruit but for the clearness and purity of its water. About a dozen well-to-do families at San Pedro send peons to Toconao to obtain drinking water, brought in casks on mule back.

So valuable are the water rights at San Pedro and in the towns near by that a *juez de aguas*, or judge of water, is appointed who decides how much water each landowner is to have. In the driest years it may be impossible for a landowner to irrigate oftener than once every ninety days, though in general he is not required to abstain from the use of water for more than sixty days. The mountain snowfalls are a matter of real importance, for upon them depend the source and flow of the Rio Atacama that quite literally "waters" the valley. The snow that falls in the cordillera about the 3rd of May is called the *nevada de la Cruz*, and that which falls about the 4th of October the *nevada de Cordonazo de San Francisco*. Though snow is a rarity in the desert it fell in 1911 down to 8000 feet (compare p. 43). In the oases it covered orange trees, vegetable gardens, and grainfields and effected a glory that was as novel as it was short-lived. It covered the mud huts thatched with grain straw mixed with earth and on melting germinated the seed, so that more than one householder grew a small crop of wheat and barley on his roof!

Corn is planted in August or September. Both it and the fruit may freeze, for frosts come as late as December and may work grievous injury to the growing crops and necessitate replanting. Furthermore, the crops are sometimes destroyed by hailstorms which occur when the wheat is heading and which are accompanied by thunder and lightning. The floods

in the river last but several hours and then subside rapidly. The river swells only at times of general rain, and it then covers the whole flood plain over a width of a quarter of a mile.

Along the line of a single valley are strung the scattered plots of precious watered land. Between them there may be nothing but gravel-strewn stretches of valley flat. Hence it is



FIG. 77—Pingo-pingo, a wild desert shrub common in the southern part of the Desert of Atacama. The photograph was taken near San Pedro de Atacama.

natural that each cultivated tract should be known under a different name and give its name to a part of the valley. The best illustration is to be found in the valley of Rio Atacama. The town of San Pedro de Atacama has about 500 people, but all about it (and to the inexperienced traveler they appear a part of it) are scattered groups of families and little villages. All told they raise the population of the district to 2000. On the maps the name of San Pedro de Atacama is applied to the whole collection of groups. Each cultivated district, or *aillo*, has a distinct name, and this name is given to the central pueblo or village as well, the use of the word *aillo* apparently being interchangeable as between land and group. Even the largest village of the group is not called San Pedro but Conde Duque. For two leagues above this nucleus are small culti-

vated tracts,¹⁰² Cucholrache, Catarpe, Tambillo, Silo, and Quito, where fruit is grown. Extending to a point three or four leagues below are Sólar, Larache, Yaye, Pácsar, Chécar, Séquitor, Coyo, Tultur, Beter, Poconche, Solcór and Cúcuter on a ridge of sand, and Tevinguicha on the border of a brackish swamp due to seepage from the piedmont deposits. Each tract or village represents some natural advantage. Here a group of algarrobo trees feed on the ground water and supply an abundance of algarrobo fruit. There a clump of chañar trees supplies nuts for the delectable chañar meal. On the edge of the swamp of Tevinguicha is pasture to be rented to the cattle drivers from across the cordillera. The soil is sandy at Cúcuter, but it has no harmful salts and if watered but twice a year yields good crops. At Catarpe are warm terraces easy to irrigate, hence beautiful fruit orchards.

A common plant upon which the Indians hereabout depend for fuel is the green chilca bush, used for firewood and for cover to the earthen walls that border the alfalfa fields. It grows rank where there is abundant water. There is much of it at Calama, at Aguas Blancas, and on the alluvial fan at San Pedro. Near the water also is a species of acacia, the so-called *sauce* (willow), of which some fifty or sixty varieties are said to abound in the neighborhood. We saw this tree at Poma also. So abundant is the pingo-pingo (Fig. 77) south of Atacama that its name has been given to a range of mountains.¹⁰³

San Pedro de Atacama is a city of *arrieros* (muleteers). Unlike its tiny neighbors it draws upon outside resources. The additional population which it supports requires food in amounts greater than the land can yield. Its wants are more varied. Through it also flows a commerce between the mountain peoples and the outside world. At San Pedro we should therefore expect trading customs and movement of population quite distinct from the feeble movements between the tiny oases. From their valley homes and upland pastures the

¹⁰² The spelling of these place names was supplied by Señor Arturo Alvarez of San Pedro de Atacama and differs in a few cases from a similar list of names given by Alejandro Bertrand, *op. cit.*, pp. 269-271.

¹⁰³ See the Atacama sheet of the American Geographical Society's Millionth Map of Hispanic America.



FIG. 78



FIG. 79

FIG. 78—Winter camp of mountain shepherds at Aguas Blancas near Soncor, Desert of Atacama, 9000 feet. In the background is the great Salar de Atacama.

FIG. 79—Temporary habitation of poles and branches on the border of the oasis of San Pedro de Atacama, used by mountain shepherds on trading journeys to the oasis.

shepherds come for the supplies of *chuño* (dried potatoes), chañar, dried fruit, wheat, and flour. Their dependence on the town is so great that in many cases they construct two huts, one at the home oasis in a ravine miles away; another in the desert on the border of the gardens that surround San Pedro. They pasture their flocks on grasses and shrubs at the fringe of settlement, rest a few days, trade, and return. A few have even gone so far as to construct a third hut on some neglected patch of soil at the common border of desert and irrigated land and there plant a few grains and seeds to help out their slender resources.

Among the oasis products are a few of which they have grown very fond—chañar (Fig. 22), for example, which may be ground up to make an ingredient for soup or made into a kind of bread or biscuit or roasted like a chestnut. Above all it is light in weight and may be carried with ease during mountain journeys. In very dry seasons the crop may be small and the owners unwilling to part with it. Then the nomads refuse to sell their ropes of twisted llama wool. Now the arrieros of the town must have these to hobble their beasts at night while on a journey across the desert. Leather thongs would chafe the legs of the mules and start troublesome sores. Moreover, they cannot be so securely tied, and the security of one's beasts is a most important care in desert travel. If the shepherd will not sell his valuable llama wool ropes for money, the arriero must exchange for them something of less value to him. Thus he reluctantly parts with his crop of chañar nuts, for which he may substitute wheat, rather than do without the wool ropes for which he has no substitute.

PASTORAL MIGRATIONS

Once in two or three years it rains in the San Pedro region; at longer intervals (up to ten years) it rains a number of times a year, and in these wetter seasons grass springs up everywhere; there is good pasture for sheep and cattle on wide stretches of pampa; and if flocks and herds are carefully distributed the forage may last a year, which is a great relief to



FIG. 80



FIG. 81



FIG. 82

FIG. 80—A drove of llamas on the border of the settlement of San Pedro de Atacama; in the background is the Western Cordillera of the Andes.

FIG. 81—Looking west across the Salar de Atacama toward the Cerros de la Sal, from a point near Toconao. An entire camp of mountain shepherds in their winter encampment. The stone shelters in which they sleep are about four feet high.

FIG. 82—Stone hut on the border of the main settlement of San Pedro de Atacama, used during the winter season by mountain shepherds.

the people of the town. In the drier years the forage is restricted to those seepage tracts where the underground waters appear that have been absorbed higher up in piedmont deposits. About the valley tracts at such times are dry slopes with only tiny patches of grass or scattered clumps of shrubs. We rode down through the *pajonal*, as it is called, a belt of yellow grass and scattered shrub that clothes the upper slopes of the mountains well above the settlements of Soncor, Toconao, and San Pedro. The upper pastures extended from 7300 to 11,000 feet along our route (Fig. 1).

In a valley with such restricted resources the people naturally take advantage of every means to increase the pasture of dry years and the size of the flocks they maintain. This is illustrated by the situation at Toconao. Two leagues north of the settlement there is a ravine called Zápar, which the landholders of Toconao visit to cultivate such crops as they can. Near and far, in still higher situations, many other spots, each having a name of its own, are visited in the time of planting and harvest. Tributary to Toconao are three other such small planted areas—Jeri, Atite, Laccira.

In order to relieve the oases pastures and the irrigated alfalfa fields, sheep are driven up the ravines in flocks under the care of men, women, and even children, to graze for two or three days upon any scrap of green that can be found. Some of the Indians have two residences, one in the mountains and one on the plains below. They come down to the rivers and watering places of lower elevations to water the stock and then return again for four or five days to the higher pastures. Below their watering places they may have even a third tract which some of them cultivate, and they may have temporary shelters at any one of these places.

When the shepherd is driven from the upper *pajonales* by the winter cold he has little choice whither to go. The desert oases may be crowded, but thither his flock must ultimately be driven. The sole though temporary alternative is to seek out the neglected spots where tiny springs water a narrow ribbon of green. There his flock wanders from one clump of shrubbery to another or gathers in greedy rings about rare hummocks of grass.

We find instead of rivalry that there is the closest and friendliest relation between the mountain shepherd and the desert dweller. The causes for this condition lie in the geographic distribution of the principal natural resources upon which each depends. The oases on the western border of the cordillera are for the most part mere dots in a vast desert. Miles of almost naked lava separate them from the belt of mountain pastures. Miles of hot sandy piedmont separate them from one another. In the sterile desert about them their own flocks, had they any, would find subsistence for only a part of the year. Hence the small size and scattered distribution of the oases make them quite as dependent on the flocks of the shepherds as the shepherds are dependent upon the vegetable food of the oases. Indeed, this supplementary relation is carried so far in the case of the smaller oases that they are merely the winter camps for the mountain shepherds, who have their own gardens which they leave to the care of the old and infirm during the greater part of the year. At Tilomonte a few patches of land are planted and then left to the care of wind and sun until the harvest is due. Almost the whole population of Soncor and Socaire are in the mountains in summer, only a remnant of aged and feeble persons being left behind to care for the gardens.

OLD CUSTOMS AND ANTIQUITIES

In the communal vicuña hunts, which are of great antiquity, these pastoral nomads on the western flanks of the Andean Cordillera show most clearly their isolated condition. Elsewhere the ancient customs have largely disappeared. The priest has substituted the ceremonies of the Christian church for the old feasts of the harvest and the chase. But the poor shepherds of the desolate country on the mountain border of Atacama still retain their old ways. Some of them are in pure form; even those that have become modified still have a strong flavor of the original paganism. Among them the vicuña hunt is by far the most interesting. Late in February or early in March, the men of Aguas Blancas and Toconao go into the mountain country in search of vicuña. On the

fifteenth day after the carnival the villages are almost depopulated. The women string threads across the valleys down which the animals are to be driven—for the vicuña will not pass a thread or rope stretched across his path. The men scatter widely in order to keep the quarry in the ravines. The



FIG. 83—El Pucará (fortress) near San Pedro de Atacama.

hunters are mounted, and when the vicuña become confused and huddled they are easily shot. He who kills a vicuña gets the skin, the most valuable part. Thus there is a strong incentive to compete in achieving the hardest part of the hunt. The rest of the animal is common property; since the hunt is co-operative, all must share in some way in the spoils.

Near the town of San Pedro, at a height of 250 feet above the valley floor, is a group of ruined stone houses that cover the site of a primitive settlement. Instead of spreading out upon the valley floor as do the peaceful and settled communities of today, the older settlements were established in strategic places. They rise tier on tier to the summit of the hill and are very cleverly situated and constructed for defense and for

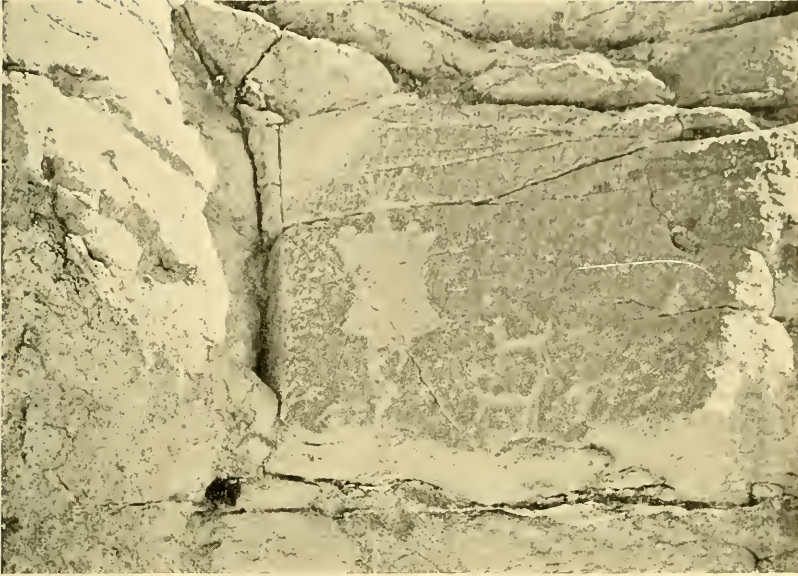


FIG. 84



FIG. 85

FIG. 84—Petroglyph at Peña, where the trail to Calama crosses a ridge formed on a belt of red sandstone. Figures of llamas can be distinguished, but the principal feature is the stretched chinchilla skin in the middle of the photograph.

FIG. 85—Petroglyphs at Peña between San Pedro de Atacama and Calama.

lookout. There are loopholes from six to eight inches square, so that one can see the slope from within, and they would also be useful for a defensive fight. On the inside of each door is a "curtain" of stone, a spur wall built out to make the entrance more tortuous, so that anyone who assaulted the door and broke it in could not see inside and would be subject to attack from stones thrown over the curtain. Inside some of the ruins are round, smooth, river-rolled stones that must have been brought from the bed of the river or from adjacent alluvium and carried within to serve the purposes of defense. Upon some of the floors are a number of round holes about four feet in diameter lined with stone, possibly for storing food and concealing or protecting water jars. They are covered with flat slabs of stone. The slope of the hill on which the ruin stands overlooks the valley, and the whole is admirably situated for observing the cultivated fields from a distance and for mutual protection. The place is called Pucará; but the name in Quechua means a fort or fortified place, so that it is more proper to speak of it as a pucará than Pucará, and it is not to be confused with the famous pucarás of Rinconada or Andalgalá described in Chapter XVI.

Other interesting relics of the ancient population are found in the petroglyphs of the region. Petroglyphs which exhibit a certain similarity are found throughout the Central Andes, all the way from central Peru to the southern end of Atacama, but there are local variations.¹⁰⁴ Beyond these limits some of those from the north of Peru are like those from northwestern Argentina, and vice versa. The llama is the principal beast represented. From the proximity of some petroglyphs and frescoes to ruins, as at the Pucará of Rinconada in northwestern Argentina, it is supposed that they pertain to the same historical period, although this does not mean absolute contemporaneity; only that the same race and the same culture

¹⁰⁴ A systematic account of the localities in which petroglyphs and pictographs are found throughout northwestern Argentina, the Desert of Atacama, and the intervening cordillera is given by Plagemann: *Über die chilenischen "Pintados," Internationaler Amerik.-Kongress Vierzehnte Tagung, Stuttgart, 1904.* Petroglyphs and pictographs are widely distributed in South America. A comparative study of their distribution such as Erland Nordenskiöld has carried out for several cultural features of South American Indian life is suggested as an interesting line of investigation.

produced both and that they belong to pre-Hispanic culture. I find no reference in any of the standard works to a chinchilla skin in petroglyph carvings and figures. Special interest attaches therefore to Figure 84, in which is represented not only the llama but a chinchilla skin spread out as if to dry.

CHANGING ORIENTATION OF A DESERT SETTLEMENT

San Pedro de Atacama is one of the oldest settlements in South America, and at first it was altogether under control of that power that issued first from the Viceroyalty of Peru and, later (after 1776), that of Buenos Aires. It formed a part of the *intendencia*, or district, of Potosí. The governor of Potosí in 1787 described the *partido* of Atacama as including in its political or ecclesiastical orbit widely scattered communities, even so distant a place as Susques, near the eastern border of the high basin country, having been annexed to the parish of San Pedro in that year.¹⁰⁵ After the wars of independence it was created a part of the Bolivian *departamento* of Atacama and the town became the capital. Trade routes between the coast and many interior points converged at San Pedro and thence mule tracks led, one to Calama and another more directly to Ascotan, along the mountain border. When Atacama was lost to Bolivia as a result of the War of the Pacific (1879-1883) the province was renamed Antofagasta, and the city of that name became the capital, leaving San Pedro as an isolated tributary town. The railway, the nitrate business, and the control by sea conspired to move the seat of authority and commercial power from its place at the meeting point of inland trails westward to the coast where it is today. The changing orientation of the life of a desert community is a characteristic feature as one dominating control gives way to another in that outside world whence spring the main impulses of trade and political control.

¹⁰⁵ Juan del Pino Manrique: Descripción de la Villa de Potosí y de los partidos sugestos á su Intendencia, in Pedro de Angelis: Colección de obras y documentos relativos á la historia antigua y moderna de las provincias del Rio de la Plata (3 vols., Buenos Aires, 1900-01), Vol. 2, pp. 13-27.

CHAPTER XIII

THE PUNA DE ATACAMA: LAND FORMS, PASTURE, AND WOODLAND

From the earliest descriptions of the mountain chains of the Andes one might suppose that they were as rugged as they are lofty and that great peaks and canyons are the rule. The frontispiece of von Tschudi's travels in South America is an almost glorious piece of misrepresentation in its attempt to show everything connected with the Andes or its borders in one composite view.¹⁰⁶ This is not to say that canyons and peaks are lacking. Some of them are larger than any we have in North America, that of the Apurimac in Peru being in places 10,000 feet deep. The Huatacondo in Chile, on the eastern border of the Desert of Atacama, is 3000 feet deep; and the Calchaquí valley at the eastern edge of the Puna de Atacama has almost the proportions of the Grand Canyon of the Colorado but without its amazing architecture. The Andes contain also the highest peaks of the western hemisphere: Aconcagua, 22,868 feet; Sajama, 21,385; and Mercedario, 21,877. Such figures of peak heights are of no value whatever unless we know how frequently we encounter them and at what elevation stands the platform from which they rise.

In view of this special character of the Andes a brief explanation of their land forms is given at this point that the subsequent narrative and description of the Puna and its settlements may be better understood. The coastal belt has already been described (pp. 149-155), the present concern is with the interior chains and plateaus that form the Puna de Atacama, the southernmost unit of the Central Andes.

After repeated crossings of the Andes in widely different latitudes I should say that it is not their height and ruggedness that is their most surprising feature but rather the wide extent

¹⁰⁶ J. J. von Tschudi: *Reise durch die Andes von Süd-Amerika*, Leipzig, 1866-1869.

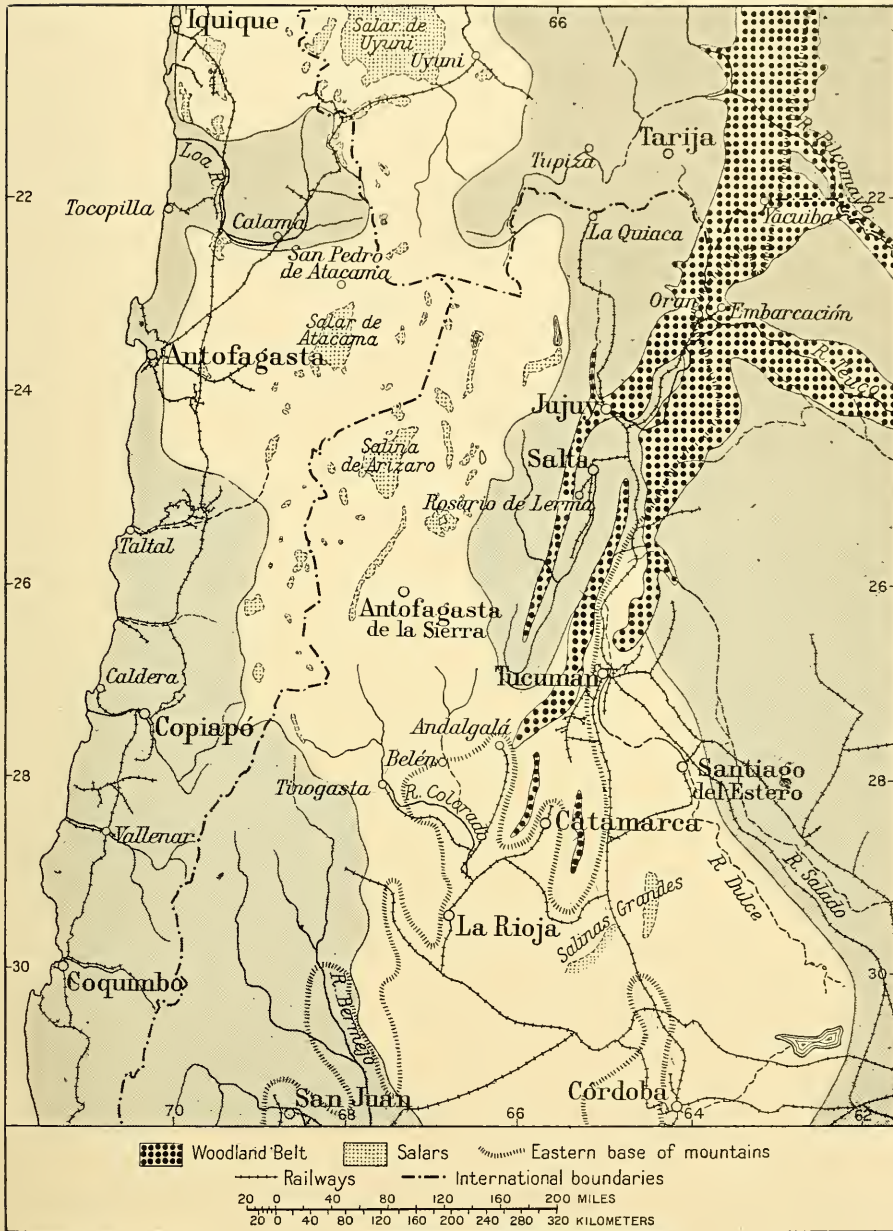


FIG. 86—Wherever such unlike regions as a dry interior-basin belt and a belt of woodland are closely associated there we are sure to find a key situation of exceptional human interest. The woodland means a steadier stream flow, irrigation, towns on the plains below, a complex life. East of the woodland belt, particularly in the Chaco, are patches and bands of tree growth, but their distribution is uncertain; and on the map above only the denser and better known belts are shown. Area of interior basin drainage is unshaded. Map reduced from the American Geographical Society's 1:6,000,000 map of Hispanic America.

of high-level plateau fragments and lava fields which form the platform upon which the highest peaks stand. East of Iquique the sky line of the western summit of the Andes for at least forty miles is almost unbroken. The top, seen from the west, is as even as if cut by a knife drawn along the edge of a ruler. The elevation of the top averages about 12,000 to 14,000 feet. From this lofty platform the snow-capped Cordillera Sililica rises several thousand feet, but it is only in this small elevation that the Andes are able to show a mountainous appearance. Their whole elevation above the sea has no expression in the relief of today. In the Puna de Atacama the average height of the basin floors is over 12,000 feet, and peaks and ridges rise to heights of only 1000 to 5000 feet about them. The Salar de Uyuni, at the southern end of the great basin of western Bolivia, is 12,000 feet above sea level, and there is little scope for the volcanoes on its border to make their distance above sea count in the relief.

The volcanic features of the Central Andes were preceded in their development by a land surface modeled to mature and even old forms over a vast extent of mountain country. There ensued wide and great uplift in the late Tertiary and Pleistocene periods. The elevation of the whole surface to higher levels was accompanied by the dissection of the mountain border as the draining streams had their gradients increased; and on the floors of the valleys the most striking features are the marks of recent and continuing dissection. Turbulent streams flowing over steep gradients dislodge and transport great quantities of waste, which is strewn over all the basin and valley floors. These marks of erosion at lower levels make more impressive the even crest lines of many plateau masses and the open and parklike character of the landscape. Grassy swards abound, and gentle, beautifully graded slopes. One's imagination rather pictures the wilder mountain scenery of the lower level culminating in bold peaks, whereas quite the contrary is the case. The top of the country has in many cases the gentlest relief. Where even crest lines are lacking there is at least a succession of graded mountain slopes showing late maturity of form. In other places all but fragments of older

surfaces may be buried under lava flows. Neither the Coast Range of Chile nor the so-called Pre-Cordillera along the eastern front of the Andes of northwestern Argentina is noted for its volcanic material but rather for its sedimentary and intrusive material modeled on smooth lines.

Were these generalizations limited to a small area they might have correspondingly small significance. On the contrary, they are characteristic of the whole Central Andes. More than that, the studies that Willis has made in northern Patagonia and others have made in Peru, Ecuador, and Colombia reveal in effect a similarity of topographic features throughout the whole Andean realm.

CENTRAL AND SOUTHERN ANDES COMPARED

Northward from the southern tip of South America the Andes Mountains are composed within a rather narrow zone, and in a single airplane view their entire extent from Chile to Argentina could be seen on a clear day. The several chains would be seen to lie so closely parallel and with such narrow longitudinal valleys between them as to have in general a rather simple appearance. One would also see the streams that drain the Argentine plain north of Patagonia extending their headwaters effectively throughout the mountain country, for the most part to the very summits and crests of the main divide. In the same way the streams running westward to the Pacific interfinger with companion streams on the other side of the Cordillera. Every mountain hollow is reached by tiny headwater tributaries. It is effective through-flowing drainage of the normal type. The desertic mountain-and-plateau country of western Bolivia and northwestern Argentina would lie out of the picture.

The relation of man to the mountains in the Andes south of the Puna is as simple as the general physiography. The valleys among the mountains are desirable for the pasture they afford in the summer season. The rivers and lakes of the mountains or along the mountain border, as in Patagonia, are sources of water for irrigation and in part even for navigation. Towns

are built not in the mountains but along their border. While the mountains offer serious transit difficulties they are difficulties not so much of distance as of elevation and snowfall, and in any case they are difficulties that are rather quickly passed. In the absence of mineral wealth, railways are built toward the mountains with the intention of crossing them, not for the purpose of exploiting the subsoil. They follow the shortest and the most practicable routes. Each one of the transitable passes is known for the relative difficulty of the road, the probability of snowfall, and the access to markets on either side. They were among the first topographic features to have a determining influence upon cities and even upon the course of history, as in the founding of Mendoza and in the development of the cattle trade and the goods trade from the older Spanish colony in Chile to the colonists who went out from there to settle along the eastern border of the Andes.

As we go northward the simple character of the mountains is lost. Beginning in latitude 30° the mountains have long extensions southeastward toward the plains of central Argentina. These offshoots enclose or nearly enclose embayments of the plain that extend like arms of the sea up the intervening valleys. The characteristic relation of basin and plain continues along the entire eastern border past the northern boundary of Argentina and through Bolivia into southeastern and eastern Peru. It is a Central-Andean type of mountain border—as characteristic and persistent a feature as the drainage of the nitrate desert or the longitudinal valley of Chile.

The general trend of the eastern wall of the Andes in its course across northwestern Argentina is not from south to north as in Patagonia but from southwest to northeast. As the mountain zone broadens, so does the mountain border become more complex. Every physiographic complexity is reflected in altered human relationships: the location of the trails, the size and situation of the cities, the whole scheme and structure of the economic life. Within the mountain belt of the Puna region in the broader Andean zone we have one of the most desolate regions in the world. Population is all but absent except in a few miserable villages crouching on the

floors of the deepest valleys, villages inhabited by primitive Indian groups who still follow the ways of their fathers and who themselves find the higher and colder parts of the cordillera so inhospitable that they go up into the altitudes only in summer to graze their flocks of sheep and llamas and thus relieve the valley floors of the pressure for forage that would necessarily follow if they all remained huddled in the narrow strips of pasture land that the uncertain streams support.

The long secondary ranges that extend forward from the main southeastern front of the Andes have diminishing elevation as they penetrate the Argentine plains. In almost all cases the summits of the outlying or detached topographic units, as well as the secondary ranges along the main mountain front, have an older aspect than the ravined border of the ranges. The topography is in a far more advanced stage of development; the mountain crests or high upper slopes, as well as the spur tops, are covered with grass, and their ravined borders are sprinkled with thin woodland. The ravines have been cut recently as a result of late uplift. Their steep head-water slopes and narrow bordering declivities are youthful features in marked contrast to the lawnlike high-level slopes which they are gradually invading.

These features are well developed southeast of Salta in the Cordillera Lambrama and again on the Cuesta del Obispo and Cerro Bayo west of Rosario de Lerma. In fact, the entire mountain mass between Rosario de Lerma and Poma is of this general type, and the contrast between it and the main wall of the Andes west of Poma and extending along the western border of the Calchaquí valley is most striking.

THE PUNA DE ATACAMA

The Puna de Atacama is the collective name given to the basins, valleys, salt-covered basin floors, mountain knots, chains, and alluvial piedmont deposits that are the chief topographic and drainage features of a belt of exceedingly high and cold country that lies between the main chain of the Andes as shown in Figure 87 and the eastern mountain wall

that overlooks the Calchaquí valley and the basins of Catamarca and Fiambalá.

The eastern border of the Puna de Atacama is rugged in contrast to the rounded ranges that stand east of that border. The contrast between the two groups of forms is further heightened by the fact that they face each other across the deep Calchaquí valley, a depression only five miles wide and extending north and south for twenty-five miles. In this narrow zone a block of red sandstone has been dropped down between closely parallel faults that bound older rocks such as slates, quartzites, and schists on the east and similar rocks with a cover of volcanic material on the west. The red sandstones were probably faulted and folded at the same time. Then came a period of great volcanic activity, probably beginning in the Tertiary and running into the Pleistocene and Recent with some glaciation in the Pleistocene, heavier on the eastern border of the mountains because of the greater precipitation there. The first terminal moraine which we saw in the ravine of Peñas Blancas above Poma was at 11,000 feet, and the best developed terminal moraine at 11,650 feet. Glaciation has flattened the valley floor so that there is an extensive pasture at 11,800 feet.

West of the Calchaquí valley are immense tracts of volcanic rock in all stages of erosion and great differences of age. Some of the youngest lava flows are on the floors of the present valleys or along the lower slopes where the valley floor once stood, the river having since cut a new narrow valley to one side of the obstructing flow (Fig. 66). Here and there, as in the valley of Peñas Blancas, are small lava-dammed lakes or their exposed floors where the lakes have since been drained.

The contrast between the younger and higher mountains on the west of the Calchaquí valley and the lower but older mountains to the east of it is heightened by the character of the

Fig. 87 (opposite)—Reduced from the American Geographical Society's Millionth Map of Hispanic America. Scale 1:4,500,000. Only the main divides are indicated, and the main peaks and passes. The term Puna de Atacama is applied to the tract east of the Cordillera de los Andes to the main eastern divide and northward approximately to the 23rd parallel. Ab.=abra, or pass; Port.=portezuela, or pass; Ap.=apacheta, or trail marker; S.=salar or salina; C.=cerro, hill or peak; V. and Vn.=volcano; Sa.=sierra, or chain; Ns.=Nevados, or snowy peaks; Ms.=Morros, or hills.



FIG. 87—Desert and Puna of Atacama (for description see opposite page).

peaks on the west. They are real volcanic cones, many of them so recent as to be little dissected and so high as to be covered with snow most of the year. It is a great lava-covered volcano-studded wall.

Upon the eastern mountain wall of the Puna de Atacama and upon the peaks that crown it there is wrung out of the air almost the last vestige of its moisture. It results that the country to the west of that wall is exceedingly dry. The precipitation is so light that through-flowing drainage is absent over a wide area. It is a dryness that is broken in a significant way but once in a period of years, and precipitation then usually takes the form of a blanket of snow which may accumulate to a depth of several feet and remain for two weeks or so. The pass at the head of the ravine of Peñas Blancas is at an elevation of 4950 meters (16,236 feet). When we crossed it in July, 1913, there were snowbanks under the steeper lava cornices near the pass, and some snow lay in small patches on the eastern side of the pass. The early morning temperature at our last camp just east of the Western Cordillera on the San Pedro trail was below zero Fahrenheit. The stream and the pool near camp were frozen solid so that we led our pack train across it as across a floor of rock. Yet there was no snow on any of the slopes round about or on the cones in the distant view. It was only when we reached the pass in the main chain that a few tiny patches and strips of snow appeared high up in the sharp but small ravines cut in the volcanic cones that stand on either side of the gateway. The stream water derived from rains and melting snows is gathered in local basins whose margins are rimmed by belts of relatively steep alluvium and whose floors contain either lakes or marshes or salt deposits or all three in varying sizes and combinations. In one basin salt may prevail as a floor deposit; in another it may be borax. The salty deposits at the bottoms of the basins are residues from evaporation and include chlorides of sodium, potassium, and magnesium, some sulphates and carbonates, and borax. The composition varies from place to place according to the sources of the material from hot springs which occur rather frequently throughout the Puna and from rain water that

has gathered chemical elements from the adjacent lava slopes which they drain.

In consequence of the greater precipitation and larger streams on the eastern border of the Puna a vastly greater amount of erosion has taken place there than on the western border of the Puna. In contrast to the feeble Copiapó River, which reaches the sea only at long intervals in latitude $27^{\circ} 20'$,

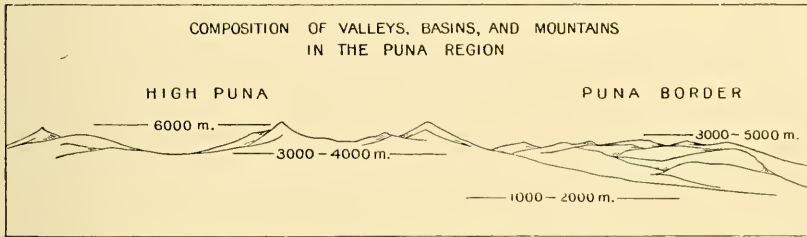


FIG. 88—Schematic diagram of the Puna and its eastern border to represent enclosed basins on the western side of and among volcanic ranges and through-flowing drainage east of them.

are the headwaters of the Colorado (or Bermejo) River in the Fiambalá district and in the Chaschuil district, where intermittent streams from at least three principal mountain masses furnish water for a widely ramifying system of tributaries.¹⁰⁷

Viewed from the trail on the Cuesta del Obispo (Fig. 63, p. 203) the eastern rampart of the Puna has a distinctly mountainous appearance; seen from the west it forms a somewhat tame landscape. The border chain has high passes and relatively low peaks. The passes run from 5000 meters to 5400 meters (16,500 to 17,500 feet), but the peaks are only a little higher; that is to say, they range in elevation from 5500 to 6000 meters (18,000 to 20,000 feet). The passes have been but little eroded, for the mountain border is in a state of extreme youth. By contrast the Cordillera de los Andes, or Maritime Cordillera, which borders the Puna de Atacama on the west, averages about 4600 meters (15,000 feet), but the peaks run up to 6000 meters (20,000 feet) or 7000 meters (23,000 feet). The cones on the eastern side of the Puna are

¹⁰⁷ Walther Penck: *Der Südrand der Puna de Atacama*, Leipzig, 1920, pp. 38-39 and 52-53.



FIG. 89

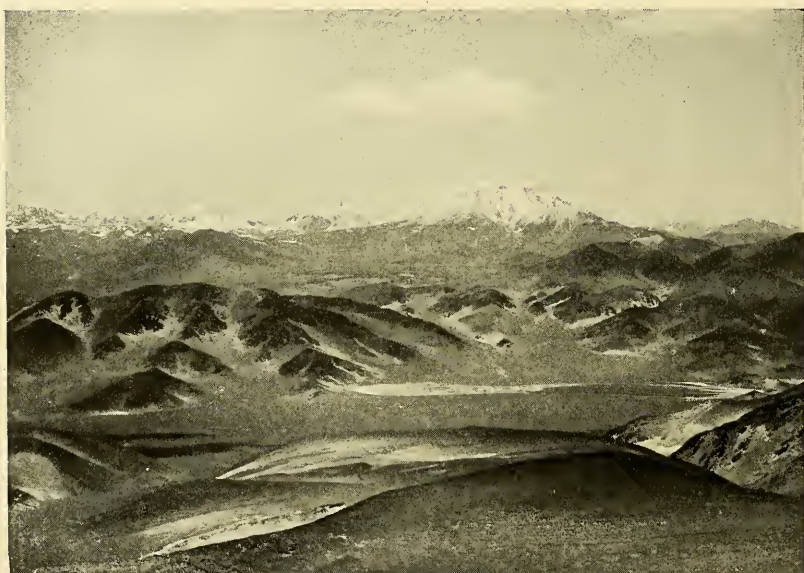


FIG. 90

FIG. 89—View from Nevado Ojo de las Losas (6620 m.) northward to the volcanoes of San Francisco and Antofalla. Shows character and composition of southwestern Puna de Atacama.

FIG. 90—View from the western slopes of Cerro Palca westward over waste-cloaked slopes of the Chaschuil depression to the snow-covered mountains of the Western Cordillera. Camera at about 5000 m. (16,400 feet).



FIG. 91



FIG. 92

FIG. 91—Chaschuil depression from 3800 m. View from east over Casadero toward southwest. Salt fields of Chaschuil floor. Old erosion surface on heights. Second erosion surface on intermediate slopes.

FIG. 92—View over the salina of Laguna Helada toward south. On the right is the culmination of Sierra de Fiambalá. Camera at 3800 m. (12,500 feet). Figures 89-92 are from photographs by Walther Penck.

low and have been built up on broad and thick sheets of lava. Those on the west are high and have been built up on a lower basement of lava.

On the earlier maps of the Puna de Atacama the mountains were represented as scattered peaks, and the intervening spaces appeared as broad plateaus. The true character of the Puna is quite different. It consists of mountain chains, knots, and isolated peaks arranged along dominating north-south lines as in the sketch, Figure 87. West of the Nevado de Cachi which forms the eastern wall is a line of salinas or salars.¹⁰⁸ These become larger toward the west. The Salina de Antofalla is 90 miles long, though but 2 to 6 miles wide. North of it is the Salina de Arizaro, the largest salar of the Puna de Atacama, 25 by 55 miles in extent; and others continue the line still farther north.

Westward of the first line of salars, which includes the Salina de Pastos Grandes, is a north-south line of peaks of lesser height and much less definition than is shown by the Nevado de Cachi. There follows a second line of salars represented by Quiron and Rincon. West of this line we come to a very important topographic feature, the Cordillera de Callalaste. Though the height of this cordillera is not great—its peaks range from 5000 to 5600 meters—yet to the west of it we have the largest salars, the most desolate country, the most inaccessible portion of the Puna de Atacama, a region practically uninhabited. East of the Cordillera Callalaste and its continuation to the south, the Sierra Famatina, are better conditions with more fresh water, a larger number of *aguadas* and *vegas*, an increase in the number of settlements, and a moderation of the hard conditions that prevail in the upper Puna. The basins are more extensive, and the drainage features better developed, with a number of principal streams that break through narrow gorges and give outlet to the Argentine plain. The group of settlements in the basin of Fiambalá, the gathering of waters at Antofagasta de la Sierra, and the settlements

¹⁰⁸ The terms salina and salar are used interchangeably in many places; in others a distinction is made between a basin floor with a moderate deposit of salt, a salina, and one with heavy deposits, a salar. In general the term salar is used in Chile, salina in Argentina.

in the widely extended valleys that unite to form the headwaters of the Rio Salado between Tucumán and Salta reflect the slightly moister climate and more nearly normal drainage that characterize the eastern border of the Puna.

The western mountain divide of the Puna is formed by the Cordillera de los Andes, which consists chiefly of a line of high volcanoes with lava flows about them. The highest elevations run between 18,000 and 20,000 feet. Upon the mountains the summer winds are from the east, the winter winds from the west, so that from December to March, as in the Copiapó region, there is a period of melting snows, and from June to August there is a period when the moist winds from the Pacific increase the snow fields and sometimes lay an extensive cover of snow over the whole of the mountain belt. The Copiapó valley receives part of the run-off from melting snow in the high volcanoes, and its flow is thereby made regular enough to support farming in the Copiapó valley—which gives a critical geographical value to this part of the Andean Cordillera of South America, in the study of human distributions.

West of the Cordillera de los Andes and for 3000 to 4000 feet below the Puna level, or at 7000 to 8000 feet above the sea, there is a line of depressions which includes the great Salar de Atacama and the Salar de Punta Negra. These are enclosed on their western side by the Cordillera Domeyko (Fig. 87). The region is considered as a portion of the Desert of Atacama, because in its irrigated sections are produced fruit, grain, and forage in abundance in contrast to the cold, desolate, and largely uninhabitable character of the high Puna country (see Chapter XII). It is quite a different world, and after the mountains it seems extremely hospitable.

The quality of the relief and drainage on the western border of the Cordillera de los Andes and about the basin borders in the Desert of Atacama is shown in Figure 93, which is a reduction from a contour map made by the Peñon Syndicate.¹⁰⁹ The map is especially valuable because so small a part of the Desert of Atacama has been accurately mapped. The

¹⁰⁹ For the privilege of using it I am indebted to Mr. George H. Carnahan of New York, president of the syndicate.

reader should turn to Figure 94 below for a similar map of the Iquique region, the two maps giving an excellent picture, the one of the eastern, the other of the western half of the desert country of northern Chile.



FIG. 94—Topographic map of the Iquique region showing the Coast Range, steep and even precipitous in places on the seaward side and smooth-contoured on the summit and eastern border. Compare Figure 93.

Upon the western mountain border, as shown in Figure 93, are deep but narrow ravines, and these carry water to intermediate levels only. None of the flow reaches the adjacent floor of the Salar de Punta Negra, and it reaches its border only at the rarest intervals. West of the salar is broken country—a series of isolated peaks, knobs and ridges arranged in no system and all alike bordered by broad sheets of alluvium, rarely affected by rainwash, débris from the long-con-

tinued erosion of the desert hills. It is noteworthy that upon this map and the similar one of the Iquique region (Fig. 94) *not a single stream appears outside the mountain belt*. Running water is entirely absent except immediately after rains, which fall at rarest intervals many years apart. The salts of the basin floors are still exposed where they crystallized out as the lakes they represent dried up, though in some cases they are covered with a veneer of dust and alluvial silt or sand.

It is an interesting discovery that the effects of aridity are self-stimulating and cumulative. In the West we have the expression "Too dry to rain," and this is literally true, for once the air becomes sufficiently dry it takes an immense amount of moisture-laden invading air to displace it or to furnish moisture enough to offset evaporation in the lower air even when there are local showers in the upper air. The rain in such cases sometimes actually fails to reach the ground.

The self-stimulating effects of dryness are seen equally well or better (because more constantly in evidence) in drainage features. Between Fiambalá and Uyuni is a broad stretch of country in which this is best seen. Only a few basins are able to collect sufficient waters to overflow the lowest point on their rim and thus to join their fluvial system with that of a basin at a lower level. Given a greater amount of rain we shall have, let us say, substantial streams like the Lipez, that flows into the Salar de Uyuni from the south, or the Mauri, that comes out of the Western Cordillera in central-western Bolivia to join the Desaguadero. The effect is to cause a junction of a number of large streams upon a basin floor in the form of a large lake or large salar or both. Upon the southern borders of the Puna de Atacama, particularly in the basin of Fiambalá, for example, we have the water supply gathered together in sufficient volume to cause channel ways to exist over the whole of the basin floor, though the streams are of the intermittent variety; and at the southern end of the basin these waters are gathered together from the subsoil in sufficient quantity to enable the stream to maintain its course through the narrow southern exit of the basin to Tinogasta and beyond.



FIG. 95



FIG. 96

FIG. 95—Zone of woodland on the mountain slopes above Rosario de Lerma, west of Salta, between 4500 and 6000 feet.

FIG. 96—Above the woodland on the eastern side of the Andes in northwestern Argentina the increasing dryness diminishes the pastures and brings about a growth of cactus which in places occurs in such dense stands as to form almost a forest.

PASTURE AND WOODLAND

It happens that the broadening of the mountain belt of the Andes of northwestern Argentina takes place in just the zone in which regular easterly winds begin to appear. The farther north we go, the more regular become these winds; and in central-eastern Bolivia, where the mountain belt is broadest, and thence northward through eastern Peru the easterly winds are the regular trades. It is in this belt that forest almost completely displaces grassland. Northwestern Argentina is the region in which the change takes place from desert plain to grassland and woodland in contrast to the true forest that clothes the eastern slope of the Andes farther north. On a simple mountain border against which blow prevailing winds we always find a belt of maximum precipitation, and there, too, the heaviest forests grow. Such a belt varies in height above sea level according to the general geographical situation and the height of the surrounding country. In the Himalayas it is from 4000 to 5000 feet, in the western slopes of the Sierra Nevada Mountains in California it is at a comparable altitude, and in the case of the Appalachian Mountains of eastern North America there appears to be increasing rainfall to the summits (4000 to 6000 feet); but the belt of densest forest in the Appalachians is lower than the belt of maximum rain because of the effects of winter snow, cold, and wind, which result in there being a cold timber line rather than a dry timber line at the top of the forest.

We found the zone of maximum precipitation on the mountains west of Salta to be marked by a belt of temperate-zone woodland between 4500 and 6000 feet. Above the woodland, scattered groves grow in favorable places, and belts of timber extend up the shadier and moister valley floors. The higher country bears a thin cover of herbaceous vegetation which gradually changes to the scattered clumps of ichu grass at the highest elevations. Up to 10,000 feet barley is grown; above that elevation potatoes are the chief vegetable product. The grasslands are the seat of pastoral population groups. In the forest, agriculture and grazing are combined. Below the forest,

a more intensive agriculture is practiced with irrigation. Those streams that have their chief tributaries in the forest belt are most constant in flow and furnish to the population



FIG. 97—Desert growth on the dry, gravelly floor of the Calchaquí valley northeast of Cachi, elevation 8500 feet. Beyond the candelabra type of cactus in the foreground may be seen the more common columnar type, the wood of which is shown in detail in Figure 98.

groups on the mountain border the means for agriculture and stock raising on a large scale.

West of Rosario de Lerma (Fig. 95) the woodland begins almost at the border of the plain, clouds hanging over the head of the lower secondary ranges almost constantly winter and summer. Traveling up the Escoipe ravine one enters a zone

of dense woodland with patches of true forest marked by tall, wide-spreading, moss-draped trees and an abundance of vines, heavy undergrowth, and the like, all with a distinct subtropical aspect both in type and in density. The abundance

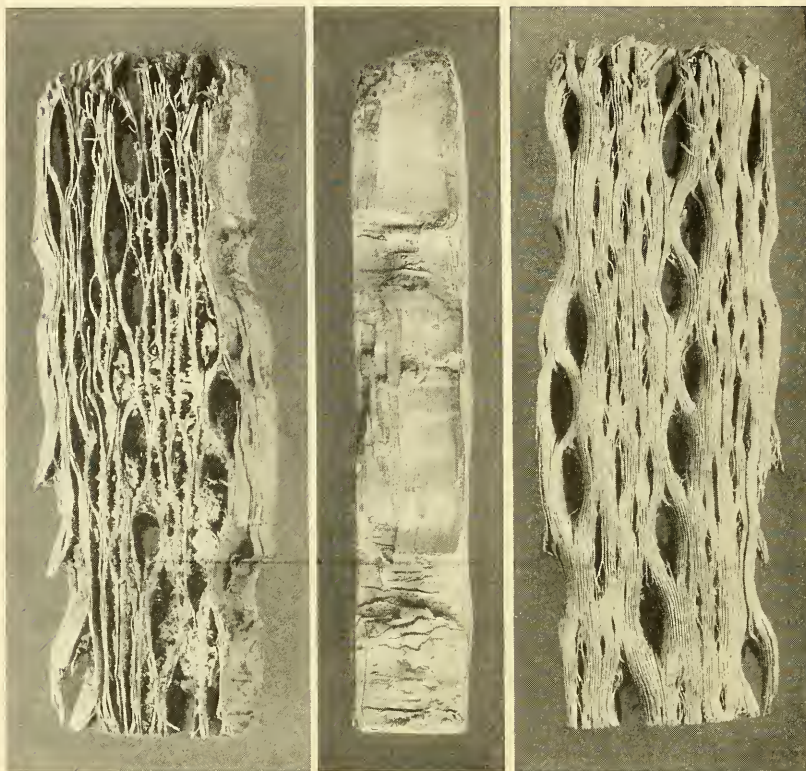


FIG. 98—The outer shell of a cactus called *cardón*. It is used in place of lumber for window frames, door lintels, furniture, and the like. The left-hand figure represents the inside of the piece; the right-hand figure, the outside; and the center, the edge. The scale is one-half natural size.

and variety of the woodland flora reflect the ample seasonal rains, but the stands of timber from place to place lack that touch of luxuriance characteristic of the true tropical forest and shown not only in the height of the tallest trees but in exuberant undergrowths and a top story of specialized climbers. At 5500 feet the tree growth stops, not altogether abruptly but so definitely that the outliers at the upper edge of the forest are

rather closely confined to slopes with a southern exposure or to valley floors with an abundance of ground water.

Above the forest the slopes are covered with an extraordinary growth of cactus. It has in places the suggestion of a forest aspect (Fig. 96). Between the upper edge of the forest and

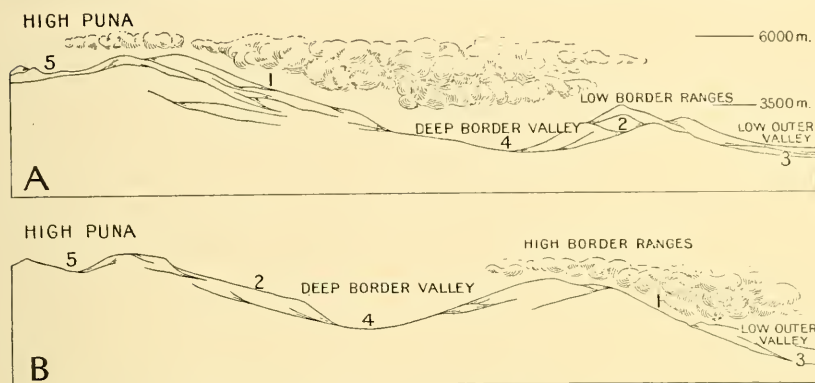


FIG. 99—Composition of cloud zone and woodland and grassland belts on eastern border of the Puna de Atacama under characteristic topographic conditions. In A the border ranges are low, the prevailing east wind of summer carries cloud, the belt of maximum precipitation is located on or near the Puna border, and both it and the low border ranges have corresponding belts of scrub and grass. Both border and outer valleys are irrigated, and the outer one may be very dry. The inner one has a large and important main stream with an abundance of tributaries. The high Puna is above the belt of heavy rains at all seasons and has only a meager vegetation of clump grass and moss. In B the high border ranges cut off the rain-bearing winds so effectively that there is a belt of pronounced rainfall (seasonal) and a growth of woodland (1) with grassy belts above and below it. The deep border valley (4) and the low outer valley (3) are both irrigated. The pasture belt at 2 in B is less pronounced than at 1 in A, being sustained by occasional showers only as the cloud belt is driven westward at rare intervals or the deep border valley fills with cloud. The valley floor of B 4 is semiarid in parts, and the stream flow is uncertain, although the high pastures of the bordering upper slopes are dependable in summer, and springs are fairly numerous.

the settlement of San Fernando in the Escoipe valley (1800 meters) are the densest cactus stands that I have seen anywhere in South America. They are distinctly better developed upon the hillsides; the floor of the valley is occupied by grasses and shrubs rather than by cactus. Farther up the valley (Fig. 62) we come to the eastern slopes of the Cuesta del Obispo, and here the trail zigzags upward to a height of 3300 meters at the crest.

Cactus appears again upon the eastward-facing slopes, and one looks down over them into the fertile valley floor, where wheat and barley and corn are produced, upon the smooth-contoured lower slopes and the terraced floor of the valley itself. It is a very pleasant landscape that is spread out to view.

West of the Cuesta del Obispo one enters a broad, waste-strewn valley floor after descending a steep and in places rocky trail from the pass. After crossing this broad alluvium-filled depression and a second narrow range one comes out upon the plain of Tintín, where the trail forks, one branch going west and southwest to Cachi, a town on the floor of the deep Calchaquí valley, and the other branch turning abruptly north to Payogasta and Poma. It was the latter that we followed, traversing the dry, waste-strewn plain in the middle of a hot afternoon when clouds hung over the Sierra de Tintín on our left hand as well as on the distant Cordillera. The plain of Tintín is covered with cactus and desert shrubs of many varieties. Figure 98 represents the structure of the wood, and Figure 97 the field situation of the chief columnar cactus, the so-called *cardón*. It is valuable for rafters and in making doors and door frames, window frames, and parts of outbuildings. We are here far above the forest and in the zone of low winter temperatures; but the cactus continues its scattered growth all the way up the valley and on the lower slopes of the main mountain wall to surprisingly high elevations. I found it up the valley of Peñas Blancas, almost a day's journey from Poma, at an elevation of nearly 13,500 feet. It was growing chiefly upon the southern (warmer) wall of the valley, partly on lava flows, partly on the coarse *débris* washed or rolled down from these flows on the intermediate slopes of the valley. It is here subjected to almost nightly frosts for a part of the year.

I found similar forms at elevations exceeding 13,000 feet in the high mountain country east of Iquique beyond the Cordillera Sillilica, where there are nearly six months of cold weather with severe frosts at night and often violent hailstorms by day, with some snow occasionally.

CHAPTER XIV

CROSSING THE PUNA DE ATACAMA

Traveling westward over the Puna de Atacama from Poma at the eastern foot of the mountains to San Pedro, west of the great cordillera, one leaves the last outpost of settled life at 11,000 feet, at the border of the mile-deep Calchaquí valley. Even by the time one has reached Poma the forest and scrub of the eastern foothills and front ranges have been passed, and the only extensive growth besides grass and shrubs is columnar cactus that extends mountainward far into the zone of frost to an elevation of 13,500 feet. The rim of the Puna de Atacama begins nearly a day's journey west of Poma, and the trail climbs rapidly to a height of over 16,200 feet (4950 meters) at the Abra (Pass) de Peñas Blancas. The last few hundred feet of the trail is over rough volcanic débris and above the upper limit of plant life.

On the western side of the pass the shepherds' corrals and huts are at a higher elevation, ranging from 14,000 to 14,400 feet. The first substantial huts are at 13,500 feet, or more than 2500 feet below the pass. We passed the first dwelling sites on June 22, camping at 14,250 feet in a ravine on the western side of the pass; and the following day, June 23, we camped at the edge of the lake and borax flat at Pastos Grandes at 12,650 feet. The minimum temperature at our camp at 14,250 feet was 14° F. on the night of June 22.

The eastern mountain wall that forms the rim of the Puna is a divide between two quite unlike worlds. From the tops of the eastern spurs one looks far down into another climatic belt to what appears to be a world of plenty. The alfalfa meadows, the barley and wheat fields, the gardens and settlements of the Calchaquí valley are the chief elements in the border scenery. West of the divide there is a clinkery, lava-covered, or waste-strewn, arid surface. It has many minor divides, huge salars, or salt-covered basins; and its immense sheets

of lava are crowned, especially on the west, by a belt of volcanoes that rise locally to 19,000 feet with passes at 16,000 feet. So scanty is the vegetation of the Puna that bare rock, sand, and salt reflect the strong sunlight of these high altitudes to the great discomfort of the traveler. Following down the sterile volcanic slopes of its basins one commonly passes over loose alluvium forming a mile-long piedmont fringe, material washed down from the higher slopes about the mountainous basin border. The material of the piedmont fringe becomes progressively finer as one descends, and it ends altogether at the edge of the flat salt-encrusted surface that forms the basin floor. The lower slopes are generally marked by a growth of green, resinous, and fragrant tola shrub; and it is in the belt of tola that the traveler comes upon water if he finds it at all. From an elevated lookout on the trail he may see at long intervals the green and naturally irrigated ribbons that thread the piedmont and mark the sites of tiny streams issuing from springs or seeps on the mid-slope. In many cases the water is brackish or quite salty. In a few cases, commonly at intervals of twenty to forty miles, sweet water may be found. The tola bushes furnish fuel for the camp fire, and the ribbon of green furnishes pasturage for the mules.

These little natural oases are called *vegas*, and their location and extent are one of the chief interests of the traveler. In their absence a dry camp must be made, and the mules must go another day without water and subsist upon dry barley, a quantity of which has always to be carried as a necessary part of the supplies. A camp located at such a point will generally have a measure of protection from a ravine bank, cut in the alluvium, and will have in front of it the white floor of the basin, quite flat, with dark patches here and there where open water stands.

DIFFICULTIES OF THE CROSSING: THE WIND

In the daytime whirlwinds sweep across the piedmont slopes and the salars, lifting their great yellowish white columns of dust to altitudes of a thousand feet and more. Everywhere are signs of the wind in long ridges of wind-blown stuff, pebbly



FIG. 100



FIG. 101

FIG. 100—Long alluvial slopes characteristic of the piedmont belt at the border of the intermont basins in the Puna de Atacama. Elevation 13,000 feet.

FIG. 101—The descent into the basin and mountain country of the Puna de Atacama after crossing the eastern border. The ichu grass in the foreground is characteristic. Elevation 15,000 feet.

pavements, and bunch grass streaming down-wind. Throughout the day the wind blows with great persistence and generally with high velocity. It ceases at sunset and generally does not start again until early forenoon of the following day. The nights are almost always cloudless with a brilliant sky. Most fatiguing are the effects of strong winds and dust day after day. Riding obliquely into the wind or down it, one finds it tolerable; but it is extremely irritating when one rides directly into it. Our route lay toward the northwest up the long eastern slope of the Western Cordillera, through the pass, and down the western slope; and this took us right into the heavy west and northwest wind that is the most striking winter feature of the meteorology of the region. We had *continuous* heavy wind in the daytime and a temperature that ranged from nearly zero Fahrenheit in the morning when we broke camp to a little above freezing most of the day. Though we were warmly clothed, the wind effect was so great that we were obliged at every opportunity to dismount and warm our fingers and toes in the lee of the ravine walls or the large boulders that lie near the trail under the pass. The constant drumming of the wind is maddening and far exceeds the discomfort of cold. It is like living next a factory whistle or a proving ground, and worst of all is the realization that nothing can stop it!

SEASONAL TEMPERATURES AND RAINFALL

We crossed the Puna de Atacama in the depth of winter, and at the half-dozen camps established during the crossing the temperature was far below freezing every night. At our coldest camp the lowest temperature was -4° Fahrenheit. The last day and a half in the mountains we rode into a most exhausting wind, with temperatures between 1° F. at 6 A.M. and 42° F. at 2 P.M. Kühn¹¹⁰ has averaged his summer observations taken from December 26 to January 12 inclusive at 16 different stations with the following results: elevations

¹¹⁰ Franz Kühn: Beiträge zur Kenntnis der Argentinischen Cordillere zwischen 24° und 26° südl. Br., *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1911, pp. 149-172; reference on pp. 162-163.

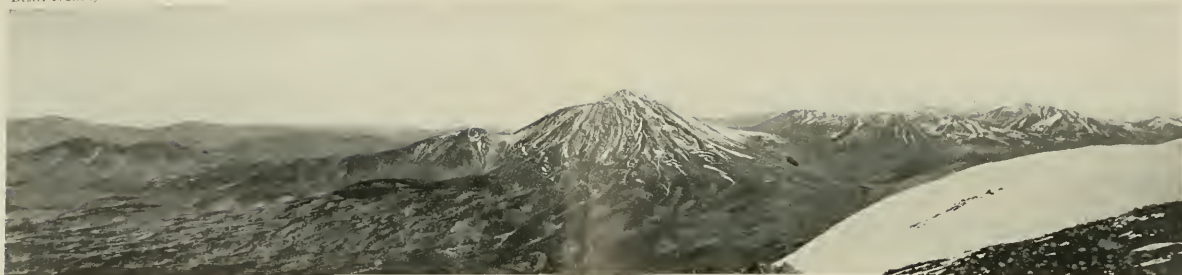


FIG. 102



FIG. 103



FIG. 104

FIG. 102—Panorama of the Nevado San Francisco (8000 meters) from the Nevado Ojo de las Losas. This is a young and little-dissected volcano with relatively fresh lava flows in the foreground. On the left rise the slopes of the Famatina chain. (From a photograph by Walther Penck.)

FIG. 103—The northern border of the Salina de Pastos Grandes at an elevation of 12,000 feet, looking southeast. On the trail from Poma to San Pedro de Atacama. See also Figures 108 and 109.

FIG. 104—Panorama of the Puna de Atacama from the crest of the mountains that crown the eastern border of the Puna. The left-hand section lies due west; the middle section northwest; and the right-hand section north of the observer.

range from 11,300 to 14,100 feet; mean maximum temperature, 21.4° C. (70.5° F.); mean minimum, -0.5° (31.1° F.); mean 10.4° C. (50.7° F.); mean humidity, 37.5 per cent. Violent rains of short duration, with thunder and lightning, fall only during three summer months of December, January, and February. During the rest of the year the atmospheric humidity is between 50 and 65 per cent. While there are no weather stations in the Puna, all of the official records from scattered stations in the country roundabout show very meager precipitation: Humahuaca (latitude $23^{\circ}10'$) has 155 mm.; Ca-fayate, in the Calchaquí valley (26°), 377 mm.; Santa Maria ($26^{\circ}45'$), 180 mm.; Tinogasta ($27^{\circ}50'$), 110 mm.¹¹¹ In these and other stations in the Andean Zone 90 per cent of the rain falls from October to March.

The Puna would be impossible to cross if the climate were less dry, for the great elevation of the country would turn the winter moisture into snow and deeply blanket the entire region. The contrast between the cold of the Puna de Atacama and that of the bordering valleys was increased during our journey by the fact that in the earlier days at the border of the mountains we had most delightful weather, somewhat like our "Indian Summer" and called by the natives after the feast of St. John (June 24), El Verano de San Juan. The guides were in great haste to reach the point on the trail where they could see the active volcano Láscar, near the pass in the westernmost chain. If the mountain is quiet they cross leisurely; when it smokes they hurry the mules, saying that the weather will be bad. So intensely cold is the winter season that the shepherds migrate from the higher pastures of the mountains to the warmer lower valleys that lie in the edge of the pampa or between the lesser ranges of the cordillera. Even at the lower elevation of 8000 feet near Tambillo, close to the edge of the great Salar de Atacama, the temperature fell on the night of our stay (June 29-30) to 5° F. (-15° C.) at 6 A.M., after a daytime temperature of 88° F. (31° C.) at 2 P.M., or a range of 83° F. (46° C.) in eight hours! The locality is not far from the end

¹¹¹ W. G. Davis: Argentine Meteorological Service: History and Organization, with a Condensed Summary of Results, Buenos Aires, 1914. See also *idem*: Climate of the Argentine Republic, Buenos Aires, 1910.

of the drainage basin of the Rio Atacama, on the floor of which are San Pedro and adjacent towns. We were then near enough so that we could just see the dark-green orchards of the cultivated section of the valley; and our guide remarked, "Ya tenemos San Pedro en bocillo" (literally, Now we have San Pedro in our pocket).

HEAVIER SNOWS MAKE LARGER RIVERS

The extraordinary thing about the severe cold of the Puna de Atacama is that snow so infrequently accompanies it. This is not merely an interesting physical fact of concern to the meteorologist. It is geographically important. Mid-winter snows that block the passes of the Puna de Atacama at intervals of several years become more frequent as we go southward towards the parallel of Copiapó, where heavy winter snows in the mountains are an annual occurrence. In a short distance of several degrees we have passed from one climatic belt into another, and the effect is immediately seen upon the settlements at the base of the mountains. The Copiapó and Huasco Rivers are the first through-flowing streams of any importance whatever that we see on the map south of the Loa valley (Fig. 86). In just the region that the snows become heavier the streams take on a more permanent quality. They have excavated deep valleys that give access to the main divide, and yet the prolonged snows make the crossing of the crest of the mountains more difficult.

Though snow in some quantities falls during every winter upon the high cordillera and all the passes into Chile, it is only at intervals of a few years that the fall is heavy enough to shut off communication completely for several weeks. As a rule the cattle traffic across the mountains is not suspended because of this danger, though it introduces a source of great anxiety. In the two great storms of July 22-26 and July 30-Aug. 1, 1911, about which everyone was still talking when I visited the region two years later, several herders and two parties of chinchilla hunters lost their lives, and nearly two hundred head of cattle perished also. The cattle got out of hand and strayed about at will, some to graze on the fresh

grass at the border of the water that runs from the springs of Aguas Calientes, others sought shelter behind angles of the gorge walls, and still others wandered about the mountain slopes or climbed up into the sheltered ravines. At one point I counted seventy skeletons picked clean by the condors that hover over the droves as they drift slowly across the Puna. To rescue the men a relief expedition had been organized, which was able to make its way into the mountains only with the greatest difficulty. The snow was from 5 to 10 feet deep in the high country and from 8 to 10 inches deep even in the desert at San Pedro de Atacama (8000 feet). Even when the crossing is free from snow, both cattle and men often reach the desert on the west scarcely able to walk on account of the dust and the cold and the terrible *viento blanco* which glazes the eyeballs of the beasts and blinds them. At the Alto de Lari (16,500 feet) on the Antofagasta road "thousands of head of cattle have left their bones."¹¹²

At short intervals along the trail little stone shelters a foot or two high are built to offer protection to travelers, and every boulder beside the trail is a refuge behind which the herders seek temporary relief from the cold wind. Coming from a high but warm valley (Calchaquí) and going to a hot desert (Atacama), these men are not prepared, like the polar traveler, for the arctic weather that prevails at intervals in the loftiest situations of the Puna. The difficulties and risks of the journey arise from improper clothing and unaccustomed exposure rather than an inherent quality of the climate itself. No amount of clothing, however, can make up for the deficiency of circulation caused by the high altitude. The effect upon heart and respiration is annoying but is not the chief drawback. The poor circulation results in loss of sleep from cold, no matter how much clothing and bedding there may be, nor how excellent its quality. During our journey we slept inside eiderdown sleeping bags stretched out on sheepskins placed on the ground and

¹¹² J. B. Ambrosetti: *Viaje á la Puna de Atacama*, *Bol. Inst. Geogr. Argentino*, Vol. 21, 1903, pp. 87-116. For a graphic description see Alejandro Bertrand: *Memoria sobre la exploración á las cordilleras del Desierto de Atacama, efectuada en los meses de enero á abril de 1884*, *Anuario Hidrogr. de la Marina de Chile*, Vol. 10, Santiago de Chile, 1885, pp. 1-299.

covered with several layers of saddle blankets. It was impossible to keep warm even under these conditions, and the loss of sleep and the bad circulation resulted in skin eruptions and eczema wherever there was chafing from the saddle during the day. So far as sleeping was concerned we were as well provided as an arctic traveler and for the same degree of cold, but the altitude reinforced the cold out of all proportion to the records of the thermometer.

The deaths among the chinchilla hunters of whom we have spoken, among the herdsmen who follow the cattle trails across the cordillera, and among the shepherds that come into the high country from the desert below are brought to one's attention by the occasional rude cross that marks the burial place of a native. Beside the trail are other marks of special interest. There is an *apacheta* with a lined chamber in which are placed offerings of coca cuds; whittled sticks and candles are also left by passing Indians, and prayers are offered for the safety of the crossing. I had seen apachetas of another variety in many places on the divides of Bolivia, northern Chile, and Peru, where, especially in the high passes, piles of rough stones are gathered together to mark the summit. Each traveler adds a stone for good luck, and thus some of them on the oldest trails have grown to be of large size. For example, in the Cordillera Sillilica, east of Iquique, there is one that stands at least ten feet high, with a wide circumference. Those of the Puna de Atacama had been made more carefully, and their use was more serious; in short, they are a kind of shrine and not merely a mark of the trail (see Figs. 6-8).

THE FORAGE QUESTION

The two principal salt basins on the route between Poma and San Pedro de Atacama are Quiron and Rincon, and neither has more than a trifling supply of fresh water. A few springs occur at the base of the piedmont; and each one is marked, as we have said, by a strip of a local pasture and a belt of tola. The scattered forage is in the form of ichu grass. The mules are hobbled and turned out to graze. Sometimes they are left



FIG. 105



FIG. 106



FIG. 107

FIG. 105—Borax lake and bordering clumps of bunch grass at 12,500 feet at the border of Salar de Quiron. For location see lat. $24^{\circ} 30'$, Figure 87, page 259.

FIG. 106—The salar of Aguas Calientes. The black surface is grass; the white of the background is salt; the white spots in the foreground are ice; the skeletons are those of cattle that perished in a great snowstorm in 1907. For location see Fig. 87.

FIG. 107—Small salar right under the eastern slope of the pass in the Western Cordillera, or main chain of the Andes, above Socaire. Note the rounded slopes in the background and the subdued relief.

to wander over the whole piedmont, but wherever possible they are driven some distance up a ravine or quebrada where it is hoped they will remain until morning. At daylight the muleteers gather tola bushes for fire and then set out to look for the mules, which may have strayed several miles from the camp and be quite invisible. When the cold is most intense they have to be watched part of the night and repeatedly driven back to a selected pasture site; otherwise they start back on the home trail, and it takes half of the following day to recover them. At such times they stop feeding altogether, especially if the water is brackish, and, though fatigued by the day's toil and by the effects of altitude, they nevertheless make their way along the trail at surprising speed. To awaken on a cloudy morning when the guides are anxious about snow and one is several days' travel from the high passes on either side and to look about for miles in all directions and see not a sign of one's transport animals is rather disconcerting in spite of the arrieros' assurance that, "When the pot boils over the mules return from up the quebrada."

In the long stretch from Rincon to Catua or Liri there is no grass—only shrubs, *llareta* (moss), and a very few lowly cacti. Among the grasses is the poisonous *vizcachera*. Horses, mules, and asses die within two or three hours after eating it, even in small quantities. The Indians say that cattle and llamas are immune, but they probably do not eat it. All the muleteers know the grass and its distribution, and if they have to pass through it they drive their mules at a gallop to prevent them from eating it. Several times our Puna guides passed the mouths of ravines with apparently good pasture and water because the grass was poisonous; and there is constant talk among the guides of the localities where the *vizcachera* abounds. Out of one pack train of ninety mules seventy-five died as a result of eating it. It has been found to give rise in the stomach of the animal to prussic acid.

In the quebradas of the mountains are *queñoa* which sometimes attains a height of four meters. Among trees it attains the highest altitude in the cordillera and forms small groves in favored sites. Its trunk and branches are twisted. In places



FIG. 108



FIG. 109

FIG. 108—Looking east at the western face of the mountain range that surmounts the eastern edge of the Puna de Atacama on the trail between Poma and Salina de Pastos Grandes. Elevation just under 16,000 feet.

FIG. 109—Belt of bushes and bunch grass along a line of water seepage at the border of the basin of Pastos Grandes. The tola bush and similar shrubs predominate in these situations, and though they are widely distributed their best stands at high elevations are in sites especially favored with a good water supply.

it forms a protection against the wind. There is a small commerce in cactus, the sole wood for construction of floors, benches, tables, etc. The best pastures for the sheep are found on the flanks of the cordillera; only mules, asses, and llamas can subsist upon the grasses of the high plateau except in quite special situations, as, for instance, at the vegas or ciénegas, the naturally irrigated spots where there is more grass than usual. In the great stretch of country that forms the western half of the Puna the shepherds do not come at all, and it is not until one reaches an elevation of 14,400 feet on the western range that signs of their occupation are found.

Of agriculture there is very little in the Puna: alfalfa and barley in special places; potatoes, quinoa, and habas, or beans. Corn is produced in valleys protected from the wind, and both cobs and corn have been found in pre-Hispanic graves and in fields and terraces now in ruins on the borders of the Puna de Jujuy,¹¹³ showing that the plant had been cultivated on a great scale and indicating either that the climate has changed since that period or that the inhabitants of the Puna de Jujuy in pre-Hispanic times imported some of their provisions of corn from lower lands or from San Pedro de Atacama across the Puna, which was then inhabited by people of the same stock. Horses cannot live upon the high plateau; only mules and asses and flocks of sheep and llamas constitute the basis of wealth. The mineral industry of the Puna is almost abandoned today because of the high cost of transport; it employs llareta as fuel for steam.

MAIL SERVICE ACROSS THE PUNA

In spite of the severe climate of the Puna, three mails a month are maintained between Salta and San Pedro de Atacama over a distance of 300 miles (480 kilometers). The mail carriers relay the mails and arrange the relays in such a manner as to travel both day and night, thus covering this great distance in six days. Sometimes the mail, like the cattle driving, is held up for two weeks by deep snows.

¹¹³ Éric Boman: *Antiquités de la région andine de la République Argentine et du Désert d'Atacama*, 2 vols., Paris, 1908; reference in Vol. 2, p. 410.

The route runs by way of Cachi. The route between San Pedro and Cachi is supported by international arrangement between Argentina and Chile, each country supplying half the necessary cost, but the carriers are Argentinians wholly. From Cachi to Salta on the east and from San Pedro to Calama on the west the mails are carried according to separate domestic arrangements made by the respective governments. The mails from the east arrive at San Pedro on the 5th, 15th, and 25th of the month and leave on Thursday and Monday afternoons for Calama, so that two mails a week are maintained between San Pedro and the railway.

PASSES, TRAILS, AND CAMPS

Three principal trails cross the Puna de Atacama. The southernmost one leaves the railroad at Tinogasta (Fig. 1), goes northward to Fiambalá, thence west and north to the head of the Chaschuil valley, swings westward at the volcano San Francisco, finds the headwaters of the Copiapó River, and descends to Copiapó. The trail has been in active use for more than a hundred years and was connected, through tributary trails, with Catamarca and other towns of northwestern Argentina long before the railway reached these points. In fact, it long gave the settlements of northwestern Argentina their most direct access to the sea.

A second trail, of much less importance, extends from Rosario de Lerma southwest to Antofagasta de la Sierra, thence west across the Salar de Antofalla to Lorohuasi, and thence northward to Aguas Calientes (Fig. 1), and to the pass of Agua de la Falda in the Western Cordillera. Thereafter it crosses the Cordillera Domeyko and descends to the nitrate desert, with branches to the country back of the ports of Taltal and Chañaral. A third trail runs from Poma to Antofagasta de la Sierra. It was formerly a goods trail but is now used almost exclusively for the driving of cattle from the ranches of Salta in Argentina to the nitrate desert of Chile. There are other trails that branch off from these three main routes to touch at settlements of minor importance and to furnish alternative routes to secondary settlements on the two

sides of the Andes. In addition to the principal trails that *cross* the Puna from one side to the other there are many other trails or traces that connect interior points.

By one or another of the three main trails and the tributaries which run to places of secondary importance every settlement has its connection with places both near by and distant; and, though the routes to be traveled may be long and difficult, time is of little importance, the cost of forage is small, and an exchange of products makes life possible no matter how isolated the spot or how distant from the larger towns of the fertile borderlands. The permanence of the trails of the Andes is natural when we consider the difficulties of so broken a passage. The commerce has varied exceedingly; but the route, the type of carriage, and the social and economic structures that are served by the mountain trail have been little changed.

In the tropical forest a trail may be overgrown with jungle if it is abandoned for only a few years. The muleteers carry *machetes*, long-handled knives, with which they constantly snip off the ends of intruding branches and undergrowth. In desert country it is the *signos del camino*, or signs of the way (trail markers one might call them), that are kept in repair. As already described these are rough piles of stone or may be recessed chambers and even mortared structures or may be nothing more than little wooden crosses such as are used to mark the graves. Again, the trail marker may be a huge cross or a tower light. Thus while in a few years a trail in the forest may be choked and even forgotten, a trail in the desert remains a trail even if there is passage over it only at intervals of several years. The trail remains a fixed feature in communication from settlement to settlement. The Inca road through the Desert of Atacama is said to be traceable over many leagues (cf. p. 103). The trails of the mountains and of the coastal desert of the Central Andes have therefore had a continuous record of use and have acquired a historical importance out of proportion to most trails in the rest of South America. When the settler comes the trails become roads or all trace of them disappears, and when new ranches are laid out new needs

arise in more closely compacted settlements. But the fixed climate of desert and mountains, the open character of the country, the thinness of settlement, and the limited population which the region can support tend to keep the trails in fixed locations, and we may read their history from the earliest colonial times, if not earlier, down to the present.

The Puna de Atacama, for example, can be crossed in almost any direction, but actually it is crossed in certain definite directions determined by the trails that follow the valleys on the border of the Puna. The passes of the border are reached by trails that climb by moderate grades to elevations only one or two thousand feet higher than the Puna basins and valleys; but on the outer side of the Puna there are very steep and rocky descents, and the valleys that offer naturally graded roads determine the location of trails. In the Pre-Cordillera—the lesser ranges that lie east and south of the great wall that constitutes the border of the Puna—the trails follow the valleys through the belt of woodland and cross by passes that have been in constant use since the time of the *conquistadores*. The Calchaquí valley was the seat of a dense native Indian population in the earliest colonial times and has continued to be a center of agriculture down to the present. A north-south trail from Bolivia to northwestern Argentina passes through it, and its importance, though variable, has continued down to the present.

Farther south, in the region of Tucumán, is the pass of Pucará, a crossing place between Andalgala and Tucumán, where the trail climbs up over the southward continuation of the Sierra de Aconquija. Troops of cargo mules pass continually over this trail, carrying the wine, hides, and dried fruits of Andalgala to the town of Tucumán and returning with sugar, tobacco, and rice. At first a mere trace, the trail has grown in importance with the development of the bordering ranches, haciendas, and towns. As the region became thickly settled in the border tracts where water may be had, the trail became more frequented and was in almost constant use up to the time that a railroad was built to Andalgala.¹¹⁴

¹¹⁴ Gunardo Lange: Las ruinas de la fortaleza del Pucará, *Anales del Museo de La Plata, Sección de Arqueología*, III, La Plata, 1892, p. 5.

THE RAILROAD AS A RIVAL TO THE TRAIL

This does not mean that the trade by trail is a constant thing or that there is a permanency to the commercial life of the towns to which the trails lead. On the contrary, there is the greatest variation in the commercial fortunes of the towns and an equally great variation in the trade by trail from town to town. To take a few illustrations. One of the old historic seaports of western South America is Cobija, now a place of no consequence at all—a place, in fact, that may be said to be practically non-existent; yet in its day it was the port of entry of a trade to Potosí (see p. 73). The distance was 575 miles. The freight included almost every sort of thing which could be found in a city of that time, though the price of goods conveyed by pack train was increased 100 per cent in the transit across the Desert of Atacama and the Western Cordillera to the central plateau. The lack of pasturage and water made it necessary to carry forage as part of the cargo, and this of course greatly increased the cost. When the mines at Caracoles, Chile, 90 miles east of Cobija, were opened, they competed so successfully with the port merchants for carts and mules that the cost of trail transportation increased immediately. It was only as late as 1892 that Oruro was connected with Antofagasta by rail, and the commerce of the trails from the coast declined accordingly. One town alone has retained its earlier importance, and that is Calama, an oasis in the Loa valley, now a station on the railway a day's journey northeast of Antofagasta.

From Calama two roads lead out to the coast, one toward Tocopilla, now an active nitrate port, the other toward Antofagasta and Mejillones. The railway has taken advantage of the same depression across the Andes that guided the routes of the earliest caravans to Calama. Many trails north and south of Calama have been tried, but there has not been discovered a single pass for hundreds of miles in either direction that can compare in low height and accessibility with this. The first effect of railroad completion on Calama was depressive. When the town lay on the route of the pack trains on the way from seacoast to high plateau, its fields and pastures

were a source of great wealth to the owners, who supplied forage to the pack mules. When the railway service took the place of pack-train transportation, Calama became only a way station on the railroad and has had to seek other sources of wealth. While it still attracts the caravan trade of a small district toward the southwest, the region of San Pedro de Atacama, it is to a large extent deprived of the advantages that its position formerly gave it in this respect. On the other hand the rapid development of the nitrate establishments in ten or fifteen years after the beginning of its decline stimulated the production of forage for the thousands of mules employed on the caliche carts of the nitrate works, and Calama is now without exception the chief hay-producing center in the northern half of Chile.

Another instance is afforded by Tinogasta on the other side of the mountains. Tinogasta is connected with Córdoba by rail, as Copiapó is connected with central Chile by the longitudinal railway. While Copiapó, like Tinogasta, is important because of its mines and irrigated fields, Tinogasta is important also because of a connection with three other towns to the north that supply the needs of a large semiarid basin, the bolsón of Fiambalá. All the towns are agricultural and are supported by irrigation, by which means crops of wheat, maize, alfalfa, oats, grapes, figs, oranges, pomegranates, olives, and other products are grown. Though the population is sparse and the farms scattered on the western side of the basin opposite these towns, their commercial needs are sufficient to have brought into being a number of considerable settlements in turn tributary to the villages that lie on the eastern side of the basin, where the four chief towns are located. In addition, both farms and villages have a connection with the Puna and the sierras, for the high pastures of these localities support flocks driven thither during the summer season. Connected with this community life and the entire group of activities on the eastern side of the mountains were the valleys on the west, of which Copiapó is the most important. With improving conditions as in the rest of Chile and with the Pacific steamship lines to serve the valley of Copiapó, its trade across the moun-

tains into Argentina diminished, and the effect was felt upon the four principal towns of the Tinogasta region, where Penck has noted signs of decay owing to the diminished use of the two ancient trade routes which converge here, the one coming from Copiapó and the other from Antofagasta de la Sierra.

What we have here is a reorganization of the commercial life of a group of mountain communities widely dispersed but having well established relations and customs that have come down to the present almost from the time of the Conquest. With the first development of trade in South America, routes were discovered whose trade has become imbedded in the commercial life of the people to such an extent that when that trade is relocated it produces a shock upon every community involved. That shock the modern railroad has supplied. It is a matter not merely of romantic interest but also of great geographical importance to trace the old trade routes and to study the trade that passed over them. The more this is done the closer is seen to be the relation between the physical circumstances of a region and the life in it as it has been lived for centuries.

OTHER FACTORS OF ECONOMIC REORGANIZATION

But there has been at work a reorganizing agency still more powerful than the railway—the large commercial companies that were called into being by the railway and have become a new instrument for the development of mines and ranches. At Salta, for example, the merchants tap the cattle-raising districts of the Gran Chaco, sending their product in part southward by rail and largely westward over the mountains to the nitrate desert. In spite of the hardships of the mountain journey, the cattle arrive in such condition as to be acceptable to the workmen of the nitrate pampa; and there is no freight charge, thus offsetting the loss in weight which the herds incur in traversing so trying a region. Mining companies requiring labor, mules, forage, food, and materials of various kinds have shifted the interests of the people, giving them a new orientation with respect to the outer world, new duties, and a measure of self-indulgence through prosperity that they

have never known hitherto. If communities are not disrupted by such changes they are at least given a new character, as one after the other of the mineral products of the region and one after the other of the railways come to be developed. A geographical group that has lived an undisturbed life ever since the Conquest finds its community life reorganized, a serious matter particularly for pure Indian communities that have carried on a fixed relation with nature not merely during the past four hundred years but from time immemorial.

CHAPTER XV

PUNA SETTLEMENTS

LIMITS TO HUMAN OCCUPATION OF THE PUNA

The mountain inhabitant of Peru and Bolivia is thoroughly accustomed to the high elevation, but this is far from saying that his system is perfectly adapted to it. Pneumonia is the most common cause of death in the cities of the high plateau, though it must be said that the immediate cause of many cases of pneumonia is drunkenness. For white occupation the effects of elevation are a great handicap, and as a rule it is only the relatively young and strong who are able to endure it. The native goes to the highest pastures with his flocks and lives in incredibly high situations, but he is by no means free from the effects of *soroche*, or mountain sickness. Curiously enough, the effects of mountain sickness vary from place to place, even at the same level, though the cause of the variation may be different among individuals. In my own case I found it dependent in large degree upon the general weather conditions, such as the existence of wind, the effect of strong sunlight upon the skin, and the amount of accumulated fatigue I had experienced during preceding days. The Indian in many places looks upon evil spirits as the cause of mountain sickness because of the variation in its effects from place to place, a matter of common experience to him.

The high-level basins of the Puna have rocky borders and intervening divides; they are scattered about in small units instead of being joined into master units, and the little fresh water that exists is distributed in short and insignificant drainage ways. As we go southward from the Salar de Uyuni (Fig. 87) we pass from an elevation of 3680 meters (12,070 feet) to 4000 to 5000 meters (13,120 to 16,400 feet), so that to the repelling effects of increasing dryness and scattered and meager water supply there is added increasing elevation with its effect upon the human system.

Added to the effects of dryness and increasing altitude as we go southward from western Bolivia to the Puna de Atacama in northwestern Argentina is the effect of increasing latitude. In short, we have a culmination of four unfavorable conditions: first, a broad mountain zone; second, a dryness so great as to be self-stimulating in its effects; third, the effect of increasing altitude; fourth, the increasing cold of increasing latitude. These causes combine to make the Puna without exception the most inhospitable part of the entire Andean section of South America below the level of permanent snow, whether we consider the winter or the summer season. What the summers gain in temperature they lose in the violence and frequency of the wind, and what the winter lacks of violent local tempest is made up for by the increasing risk from heavy snowfall that covers the whole surface and fills the passes and ravines with impassable drifts.

Unlike the shepherds of Peru and Bolivia, who pasture their flocks the whole year round at the highest elevations because they are able to endure the few weeks of cold weather at the height of the winter season, most of the shepherds of the Puna de Atacama are driven out for an entire season. It would be impossible for them to live the whole year through at most of their camp sites in the high mountain belt. When they come to the lower valleys they must come, not as vagrants but as owners, with rights; else their migratory system would be impossible. They customarily leave a part of the community, consisting chiefly of boys and old women, at the lower stations to guard their fixed property, while they drive their flocks to the high pastures, and especially to care for the fields and the limited crops. When the winter cold sets in the shepherds return from their tiny corrals perched on the mountain sides and come down to the lower valleys, where the fattened flocks graze upon the scant herbage of the valley floor and the dried stalks of desert grasses.

POLITICAL DEPENDENCE

The settlements of the Puna de Atacama are governed from the town of San Antonio de los Cobres, which is the capital of

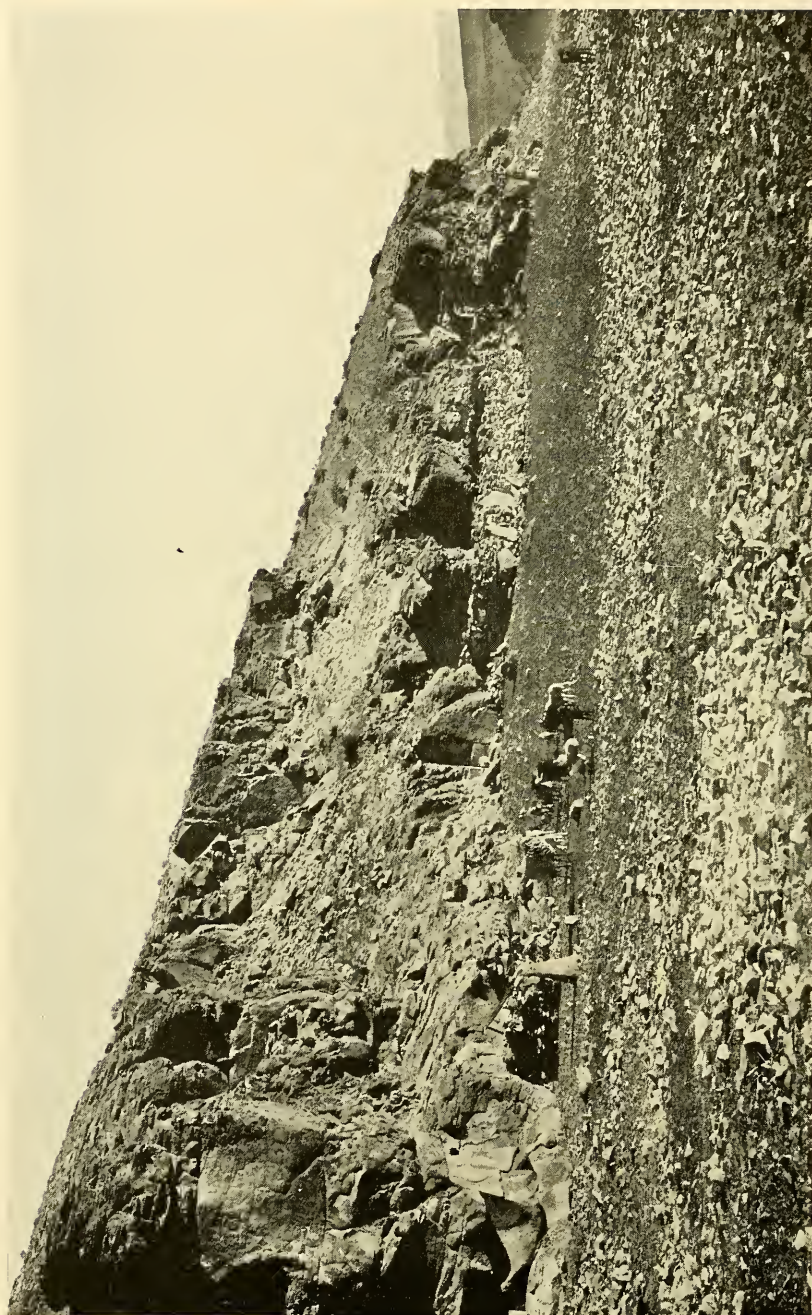


FIG. 110—Corrals and stone shelters near the basin of Pastos Grandes, Puna de Atacama, at an elevation of over 13,000 feet.

the Territorio de los Andes, one of the ten "territories" of the Republic of Argentina. In the Indian view the lack of interference in local manners and government by the central authorities is a great advantage. Certainly it would hardly be worth the while of the central government to attempt either to tax or to control the slight commerce that passes from hamlet to hamlet over the difficult mountain ways. The Indians enjoy a high measure of independence and of detachment, and in this respect their life is little altered from the conditions of the last four centuries. The Puna was a part of the territory of Bolivia down to the time of the War of the Pacific. So distant and nearly valueless a region was given little thought, and sovereignty was purely nominal until 1883 when the settlement of the War of the Pacific was made. By the terms of the Treaty of Ancon new boundary lines were designated, and the Puna passed into the possession of Chile. In 1899 Chile ceded the territory to Argentina as a result of an arbitral judgment by the United States, and in 1900 it became a part of the national domain of Argentina. In 1901 Argentine officials made the acquaintance of the Indians of the region and entered into actual possession of the new territory. It was then that the Indians petitioned to be let alone and to maintain their ancient rights of pasture and occupation, and to this the government has wisely consented. The matter is important, because, from colonial times until the present, property boundaries have been vague, and there has been no actual and effective occupation by white men. Some of the bordering concessions to large landowners take in indefinite portions of adjacent Puna. This is all the more serious to the Indian inhabitant because in his view private property in land does not exist.

DISTRIBUTION OF SETTLEMENTS

Of isolated settlements in the Puna there are many—in some places a single hut with two or three families or again a cluster of five or ten huts and a string of corrals. In the Argentine census of 1914 the population of the whole Territorio de los

Andes is given as 2487 over an area of 90,000 square kilometers, (34,750 square miles, nearly the area of Indiana). Distribution by departments is thus: San Antonio de los Cobres, 961; Antofagasta de la Sierra, 378; Pastos Grandes, 268; Susques, 880. Among the settlements of the Puna the three most important because of their connections or the number of

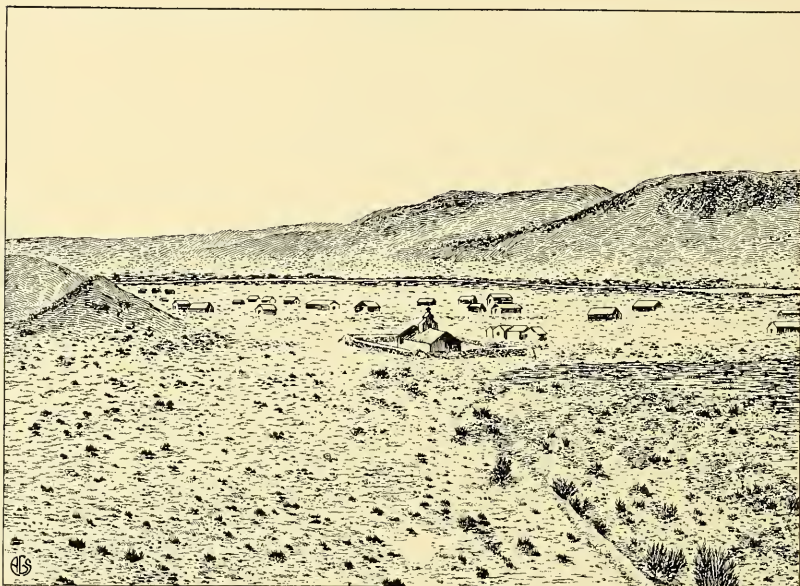


FIG. 111.—Pen sketch of Antofagasta de la Sierra drawn from photograph on page 71 of Vol. 1, *La Frontera Argentino-Chilena, Demarcación General*, 1894-1906, Oficina de Límites Internacionales, Buenos Aires, 1908.

permanent inhabitations and their history are Antofagasta de la Sierra (Fig. 111), San Antonio de los Cobres, and Susques. Their elevations are respectively: 11,319 feet (3450 meters), 11,975 feet (3650 meters), 12,467 feet (3800 meters) and their populations, 250, 800, and 400.

Among the places mentioned above, Antofagasta de la Sierra has the largest extent of cultivated land. It can boast of 8 hectares (20 acres) of alfalfa besides 675 hectares (1660 acres) of natural pasture watered by the discharge of the Antofagasta River, on the left bank of which stands the village. The place consists of about fifteen occupied huts, and there is

in the settlement and tributary to it a population of about 250 souls of which about 100 are in the village itself. Judging by the number of abandoned huts it must have been of greater size in times past. The year round hundreds of cattle, sheep, and llamas graze upon the surrounding pastures (*pastos de vegas*), a short marsh grass interspersed with *paja brava*, or *pajonal*, a stiff clump grass less than a foot in height as a rule. Pingo-pingo (Fig. 77), tola at higher altitudes, ground moss, and the poisonous vizcachera also grow hereabouts. To the pastures about the settlement are driven in winter the herds and flocks that range the cordilleran pastures (*pastos de cerros*) in the more tolerable season of summer. Here, too, graze the cattle from lower valleys sent thither to winter, as for many years past, by the cattle exporters of the department of Belén (Catamarca). Vicuña and chinchilla hunting are supplementary occupations. The exportable products, such as wool, meat, and skins, are taken either to Tinogasta on the south or to Salta on the northeast and exchanged principally for wine, brandy, corn, and wheat. The place benefits from its position as the meeting place for trails which penetrate the Puna, en route to Pastos Grandes, Copiapó, and San Pedro de Atacama. From the two last-named it is distant 10 and 7 days' journey respectively.¹¹⁵

The names of the other minor settlements in the Puna de Atacama are as follows: Rosario de Atacama, Pairique Chico, Pairique Grande, Olaroz Grande, Olaroz Chico, Coranzuli, Catua, Santa Rosa de Pastos Grandes, and Pastos Grandes. Aside from those mentioned above, almost all the names on the map are only isolated Indian huts abandoned or temporarily inhabited or, as is often the case, mere camp sites which are well known either because they are situated at the crossing of trails or because of the good quality of the water and pasture or because they are on the border of the grazing grounds of a given village. These places are occupied for a short time only; for the greater part of the year the inhabitants follow their flocks into the mountains and camp where the pasture is best

¹¹⁵ Catamarca y la Puna de Atacama, *Bol. Inst. Geogr. Argentino*, Vol. 20, 1899, pp. 133-149.

for the moment. When Éric Boman reached the village of Susques in 1903 he found it quite deserted. He sent the gendarme to examine all the huts without meeting a single person. He learned that the Indians came to the village only on feast days!

On passing the salar of Pastos Grandes we stopped at a typical shepherd's site such as occur not infrequently in the eastern and warmer half of the Puna de Atacama: an isolated settlement consisting of a few small stone corrals and a stone hut built integral with a steep lava cliff. It is occupied by two families throughout the entire year. The elevation is over 13,000 feet. Some of the huts elsewhere are of stone or earth stoutly made and thatched with ichu grass. The hut in Figure 113 stands at the edge of Ciénaga Grande, at 13,250 feet, just west of the eastern rim of the Puna. In places the houses are occupied during the summer months only and then merely as a base of supplies for the wide-ranging shepherds or as a gathering place with others on special occasions. The owners also leave for long carrying journeys or to winter in the villages of the warmer valleys where they have access to markets. They bar the windows and lock the doors, leaving utensils and household goods behind except such as they can readily carry.

Settlements of a few houses and families which are insignificant from the standpoint of population have very great importance to the traveler, and it follows that they are widely known to all the traders and to the Indian cattle drivers and *arrieros* and the chinchilla hunters, yet they are really quite insignificant from the standpoint of the large currents of trade at the border of the mountains. In a few localities are mines, and from all the eastern line of salars salt of good quality is extracted to be carried to the villages and towns and the cattle ranches in the eastern valleys. Where they are most accessible the borax salars are worked, though to a very limited extent.

THE LIFE OF A PUNA VILLAGE

The best description of the life of a Puna village is by Éric Boman in his excellent study, "Antiquités de la Région An-

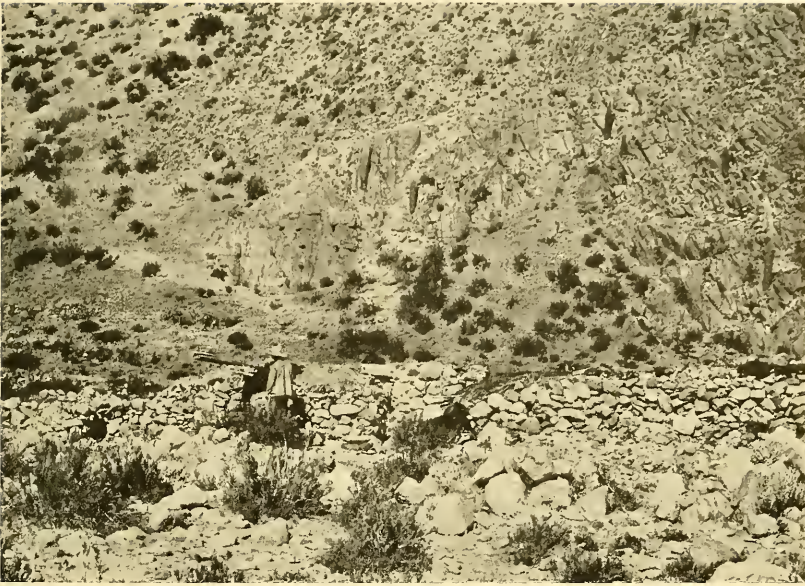


FIG. 112



FIG. 113

FIG. 112—Stone hut and corral at 12,100 feet in the ravine of Peñas Blancas above Poma in the belt of high mountain pasture.

FIG. 113—A stone and an adobe hut with wooden doors made of cactus stems, a thatch of grass, and a pile of tola bushes for firewood before the door. The elevation is 13,250 feet on the western side of the eastern chain of mountains that forms the border of the Puna de Atacama where it overlooks the Calchaquí valley.

dine." The paragraphs that follow are based almost entirely upon his account of the life of the community at Susques. The richest Indian of the district of Susques had at the time of Boman's study (1903) 500 sheep, 400 llamas, 150 asses. There are some goats in the region, but the climate is unfavorable for them. The flocks are pastured over an area 40 kilometers south and 60 kilometers north of the village, and to protect the flocks the Indians are obliged to pass all their time on the pasture grounds. The whistling of the Indian and an occasional stone thrown from a sling keeps a flock together and drifting in the direction of fresh pasture, the shepherds constantly twisting wool into yarn as they drive the animals before them. In some seasons the sheep perish in large numbers of the cold, entire flocks having been killed in this way.

An Indian will hardly ever kill a llama or sheep for food. He considers that the beast is so much capital and that he must use only the interest upon this capital, that is the wool; and, if it be a llama, there is also the service that it can render in the transport of merchandise. When a beast is killed its wool is taken off or its pelt is dried in the sun, without salt. Its flesh is made into charqui and is used sparingly with corn, potatoes, and the like as stock for soup, the main dish for the family meal. Salt obtained from the salars and pepper (*aji*) from the lower valleys are added. Fresh roasted meat is a great luxury and is eaten only on the principal feast days. The Argentine puna is often considered as the southern limit of the use of coca, but it is really used as far south as Catamarca and La Rioja, especially by muleteers who go back and forth to Bolivia. Coca is raised in the eastern parts of Bolivia and Peru at an altitude above 4000 or 5000 feet, but so far as I know it is not grown in Argentina at all. The Indians of Susques import their coca, smuggling it in across the frontier, the authorities being unable to stop the illicit traffic. Corn is also imported from the lower valleys, quinoa being kept as a reserve in case corn is lacking for any reason. By way of exchange they have asses, hides, wool, and woven stuff. The asses are sold in Bolivia and are especially serviceable, for

they will live where mules cannot stand the meager forage. The principal market for the sale of asses coming from Susques and other parts of the Argentine puna is Talina in the province of Sud-Chichas, Bolivia, close to the frontier. Rarely do the Indians of Susques go farther north, to the great Bolivian fairs, as those of Uyuni. They exchange their asses, llamas, and sheep for coca, hats, musical instruments made by the Indians of Bolivia, and the like.

THE ANCIENT SALT INDUSTRY

An important part of the commerce of the Indians of Susques is in salt gathered "raw" in certain salars, where it has crystallized out in a nearly pure state. The basin of Salinas Grandes has such a deposit. It is an immense horizontal bed of salt, varying in thickness from a thin crust to one that is two feet thick with an extent of 1500 square kilometers. There are many other salars or salinas of larger or smaller extent throughout the Puna. In the pre-Hispanic period Salinas Grandes furnished the inhabitants of the valley of Jujuy and Salta all the salt that they required; and this it has continued to do even down to our times, for it is cheaper from this source than if imported by rail. The method of extraction is primitive. The Indians who live in the Quebrada del Toro leave their homes and travel 150 kilometers (90 miles) to the salt beds, driving a train of 10 or 20 asses. Llamas are but little employed for transport at the present time. An Indian takes along his whole family at times, at other times two or three Indians join to make the journey, each one with four or five asses. The camps of troops engaged in the business are interesting to see. Blocks of salt are arranged in piles; the family sit about the fire and roast their maize. The llamas graze near by or are secured in the usual way by a rope of twisted wool run about the necks of a herd standing heads-in, the stiff-necked beasts being so stupidly dignified as never to think of dodging under the rope! The Indians cut the salt in blocks a foot square, weighing 40 to 50 pounds, put one on each flank of the ass or the llama, and take the pack train to the town

of Salta or Jujuy, where the salt is sold for about 15 cents gold per block. The asses travel very slowly, and the Indians require about a month and a half to go from their huts to the salt beds, thence to the city, and back again to their habitations. A journey of 250 miles over a month and a half gives them about 40 pesos in return. Corn is taken in exchange for the salt as a rule. They have to pay for part of the forage they use on the way and also a government tax.

In their travels the natives of Susques do not enter a city. They camp in abandoned or worthless places in the suburbs and do their business with special merchants with whom they are accustomed to deal. The *capitán* of the town at the time of Boman's visit, though he had often gone to the little tributary towns about Salta, had never visited the principal plaza of Salta, had not seen the cathedral, yet had for the bishop there a veneration as great as his ancestors probably had for the Incas. During the time that they are near such a town they never speak with other Indians whom they meet.

CONSERVATIVE CUSTOMS AND BELIEFS

Children are taken if necessary to great distances to be baptized by a priest—some even to San Pedro de Atacama on the farther side of the cordillera; others are baptized by the priest who annually visits Susques. The Indians also go to San Pedro to be married. A local Indian reads the service in the church of Susques without understanding a word of it and also conducts the burial service. A certain number of children are born out of wedlock and have no hesitation in mentioning it and in giving the name of the father. A great many of the women have children by different fathers before marriage, and the number of children increases the marriageability of the young mother, children constituting a sort of marriage portion since each one of them is capable at the age of seven or eight years of caring for a certain number of sheep or llamas. Such children are adopted by the father on marriage and are considered equals of the legitimate children born later. The fortune of an individual depends considerably

on the number of children he has, for this determines the number of beasts he can pasture. While loose relations are tolerated within the tribe, relations between a woman and a stranger, Indian or not, are immediately punished by expulsion from the tribe. Of 22 married couples in Susques only two had no children at the time the village was studied. The other twenty had seventy-nine children, forty-four boys and thirty-five girls. In spite of the hard conditions of life at Susques the ancestral character is strictly maintained; the women do not marry strangers, and the people never abandon their arid lands to emigrate to more desirable regions.

The Indians of Susques signal each other at night by lighting a fire upon a high mountain just north of the village; in the daytime columns of smoke serve the same purpose. A certain number of fires indicate that the Indians are to assemble in the village; a different number may signify "Danger; hide yourself." Ground is considered as common property; houses belong to the individuals that construct them. If a stranger comes he is refused water, fire, and food. They seek in this way to keep out of their country those who would take away their lands and make conditions of life difficult. A police agent who visited Susques was given two or three sheep; then the Indians disappeared leaving him without other food and without forage for his mules, and he was obliged to leave.

The curious mixture of Catholic rites and pagan beliefs of which we have spoken in the case of Tarapacá (p. 72) is also illustrated here, as indeed in hundreds of places throughout the Central Andes. Questioned about an apacheta, an Indian responded that it was dedicated both to the saints and to the Inca deity, Pachamama. The principal saints are those that are considered patrons of beasts. St. John is the patron saint of sheep because he is generally depicted accompanied by the figure of a lamb; then follow St. Anthony, patron of llamas; St. Raymond, patron of asses; St. Bartholomew, patron of goats. Two prayers are offered by spinners of wool, the first without doubt addressed to Pachamama and the second a curious mixture of appeals to Pachamama and Saint Anne, the Christian patroness of spinning.

On traveling in the cordillera there are invocations to Pachamama designed to avoid fatigue and *soroche*, or mountain sickness. To propitiate the evil spirits of the cordillera an offering is made on passing or stopping at an apacheta, or a stone is carried from a ravine or valley and placed on the apacheta to add to those that have been accumulated in like manner through the centuries. Christian influence is seen in the crosses, sometimes twisted about with red wool and planted in an apacheta. Special care is given to the wool used in this way. A translation of the Quechua formula in salutation to an apacheta runs as follows: "Father Apacheta, receive this, my offering of colored wool, these leaves of coca. Deign to help me in all my labors!" A translation of the prayer for re-assembling sheep or llamas when they have become frightened and have dispersed runs substantially as follows: "They have disappeared. Where can they be found? Is it possible that they can be found? Where are they? Are they far? When shall I be able to overtake my sheep? I have already met them. All are here. A lamb is missing. A fox has taken it from me." There are invocations to Pachamama relating to the shearing of the sheep; a prayer that they may breed abundantly; another with reference to the marking of sheep; and a ceremony of marriage between two young llamas, a male and a female, attached to each other, the whole accompanied by suitable invocation.

The ancient Peruvians worshiped as divinities and as oracles certain high mountains, certain sources of water, certain rocks, certain trees. All these are called *huacas*, a name also applied to idols of stone or of wood worshiped as divine protectors of a tribe or of a province. The places where the idols are kept are supposed to be the residences of the divinities, and these are also called huacas; the tombs and the bodies of their ancestors likewise. The Indians of the Puna de Atacama still believe in huacas in the first sense of the word, that is, as the supernatural inhabitants of certain localities. They relate that one such huaca is in Salinas Grandes, that persons have suddenly died on seeing it, and that others have lost their reason. This is an enormous black bull with eyes of fire.

Another one, which is a very large sheep, neither male nor female, is in the Laguna de Pozuelos. It is dazzling white in color, leaves the lake at night, rejoins a flock of sheep of the Indians, and disturbs them. Sometimes the Indians try to corral the flock and capture the huaca, but it always disappears. It is thought that this is a good sign, as it will eventually increase the reproductive powers of the sheep. On the 2nd of August all the Indians of the Puna de Jujuy attach to their fingers, particularly the small finger, a twisted thread designed to keep them from sickness and harm in the course of the year. Others attach a thread to their legs or arms. On the occasion of the feast of the patron saint of Susques (Our Lady of Bethlehem) the images of the saints are decorated and borne about with chants and ceremonies of the Christian church mixed with ancient rites. The images, preceded by musicians and standards, are carried at first to the four small chapels at the four corners of the court of the church and then to the four apachetas located on the heights north, south, east, and west of the village, after which they are carried back to the church.

THE PUNA DE JUJUY

That part of the high country of Argentina between 22° and 24° south latitude east of the Puna de Atacama is known as the Puna de Jujuy.¹¹⁶ It has pertained to Argentina since the Wars of Independence. The Indians of the Puna de Jujuy number 12,000 and live in an area of 27,500 square kilometers. The principal villages are: Yavi (494 inhabitants), La Quiaca (about 100), Santa Catalina (179), Rinconada (150), Cochinoca (117), Casabindo (85), and Abrapampa(?).¹¹⁷ They resemble the Indians of Susques but, living at a lower elevation, have more resources: beans, potatoes, alfalfa, and fair pasture for the support of sheep and asses. They also have easier communication with Bolivia and the lower regions

¹¹⁶ On the map Figure 87, p. 259, the Puna de Jujuy may be identified as that part of the highland lying east of Susques and including Salinas Grandes.

¹¹⁷ Éric Boman: *Antiquités de la région andine de la République Argentine et du Désert d'Atacama*, 2 vols., Paris, 1908; reference in Vol. 2, p. 470.

of Jujuy. Prospectors come more frequently. The land is divided among a small number of white proprietors almost all of whom live in the town of Jujuy. Each property has an enormous extent and is occupied by a hundred or more Indians who must give up to the proprietor the greater part of the production of their small troops and, in addition, give personal service when it is required. The greater part of the owners never visit their land in the Puna but are content from time to time to send an agent to settle problems among the Indians and return with supplies. The relation of the Indians to their masters is much like that which obtained under the system of Spanish *encomiendas*.

The Indians here are shy, reserved, and timid, tending to abandon their huts on the approach of a stranger—probably a response to the fact that they have been pillaged by bandits, which formerly overran the Puna de Jujuy, and to the excesses of certain civil and military authorities. They are not able to assimilate European civilization in spite of the fact that some of them are workmen in the mines and the borax establishments (since only they can stand the rare air and the cold). As a whole they have no capacity to mingle with others or to improve themselves, even though occasionally one of them rises to a position of responsibility and confidence and establishes strong relations with the whites.

While the economic and social condition of the Indians of the Puna de Atacama is substantially the same as at the time of the Conquest, there have been certain ameliorations. The most important one was brought about by the introduction of sheep. Formerly the population was dependent entirely upon the domesticated llama. The pasture grounds are too dry for alpaca, and the forage is less suitable for the alpaca than the short, thick mat of green grass growing in moister situations under the snow line of the loftier districts of Bolivia and Peru. Undoubtedly some wool was obtained, then as now, from the pelts of the vicuña and guanaco. But it was certainly an important addition to the economy of the Indian to have the domesticated sheep. The wool supply is more dependable and can be sold after shearing, and the skins of the slaughtered ani-

mals also have a market value. There is greater certainty in breeding, and there is established a better medium of exchange with the towns. The frequent intertribal wars of the border region of the Puna have given way to a state of settled life and security. The trails are safe, and the needs of the towns absorb the output of the plateau Indian. Yet in spite of these things the old forms of life persist. The old types of architecture, the search for mountain pastures, the coming and going of flocks and traders—these things continue almost unchanged from the conditions of two hundred years ago.

CHAPTER XVI

HABITABILITY OF THE PUNA IN THE PAST

In view of the notable civilization developed at the older cultural sites in the Central Andes, not only at Cuzco and Tiahuanaco, but in many other places on a lesser scale, it is natural to think of human life as going back so far there that it may have been affected by the uplift of the mountains. We know the mountains to be young. They have attained their present great height since the Pliocene (p. 254). In the great period of Andean uplift in South America man is known to have inhabited North America. If he also then inhabited the southern continent he would have felt at least the latest climatic effects of the uplift.

SHIFTING CLIMATIC BELTS ON THE MOUNTAIN BORDER

Sites of settlement that were once at a lower altitude and therefore warm enough to be cultivated might now be so cold as to support only grass for grazing animals. A little change might conceivably have far-reaching influence upon population. Sir Clements Markham¹¹⁸ once speculated upon such a possibility. An elevation of 500 feet would have a pronounced effect upon human distributions at the upper limit of settlement. In the Puna de Atacama the belt of pasture would be shifted upon the mountain slopes. The volume of springs and the discharge of streams would be changed from place to place. There would be a shifting of the edges of the belt of woodland shown in Figure 86. The upper limit of the growth of cereals and vegetables would be pushed down the mountain side to an extent roughly corresponding to the uplift. How delicately these products are now balanced on basin floors and mountain sides may be seen at Lake Titicaca. Corn is grown only at the lake border. Barley ripens on the surrounding slopes if the elevation does not exceed one thousand feet above the

¹¹⁸ Clements Markham: *The Incas of Peru*, New York, 1910, pp. 37-38.

lake. Only near the lake in little hollows along the shore can strawberries, lettuce, and other vegetables be grown.

An accurate survey of the shore lines of the lakes that spread their waters over the depression of the plateau country of the Central Andes would be a contribution to the study of the question of uplift in its effect upon man. The shore lines about many of the lake basins are still quite fresh and may be seen even from points many miles away as a thin white or light yellow line rounding the promontories and running up hollows and ravines. There has been no major modification of the landscape since the basins were filled with water. Accurate mapping of the shore lines would tell us whether they stand level today as they must have done at the time of their development. If such mapping should show that broad regional tilting occurred, that the landscape has been deformed since the lakes have disappeared, it would throw at least a part of the period of deformation and uplift of the mountain belt into the period since the great Ice Age and increase the probability that the last of the great changes of climate and elevation in the Central Andes occurred during the period of human occupation.

THE PUCARÁ OF ANDALGALÁ

We turn to some specific illustrations of the manner in which slight changes of climate may affect human occupation, whether such changes are brought about by uplift of the earth's crust or by other and more general causes affecting the whole world. Gunardo Lange, in the publications of the Museum of La Plata¹¹⁹ has described the ruins of a hill bordered by steep slopes, the long axis of the hill running from south to north. There is a principal fort on the broadest part of the summit and an advanced fort farther north on the highest point of the hill (Fig. 114). The material of the fortification consists of stone without mortar. The walls have an exterior height of

¹¹⁹ Gunardo Lange: Las ruinas de la fortaleza del Pucará, *Anales del Museo de La Plata, Sección de Arqueología*, III, La Plata, 1892. See also Carlos Bruch: Exploraciones Arqueológicas en las provincias de Tucumán y Catamarca, Univ. Nacional de La Plata, Biblioteca centenaria, Vol. 5, 1911.

about three meters and are provided with portholes for a lower line of defenders and a bench half a meter broad for an upper line of defenders.

Although there is no available water at the summit of the hill at the present time, there is a small water supply just below the summit on the western side of the Aguada de Chilcas; and Lange supposes that this source of water supply, now 140 meters outside the wall of defense crossing the ravine in which the water occurs, was within the wall at the time the fort was in active use; that is to say that the rainfall was greater and that the stream issued at a higher point in the ravine. He tentatively concludes that the fort has an extension so great that it could not be manned effectively by less than 7500 warriors. Assuming one warrior to each four persons, he further supposes that there must have been 30,000 souls, all told, living within the fort or closely associated with it in time of extreme danger or warfare. He does not believe that the fort was built by ancestors of the present Indian inhabitants whom the Spanish conquered but by people more civilized who lived in earlier times, and he assumes that period to have been more than four hundred years ago. The present inhabitants are pastoral people, herding flocks of sheep and hunting the guanaco and vicuña. They occupy the northwestern part of the Province of Catamarca, use an original idiom, live in the most primitive condition in round stone huts, often without a roof, and employ utensils that appear to be completely devoid of all ornamental work. Even allowing for the effects of the Spanish Conquest he can hardly see how so primitive a people could be the descendants of the illustrious folk that constructed the great fortress of Pucará. The case of the Aguada de Chilcas at Pucará is a matter of great importance in the history of past settlements and in the development of settlements in the future. These examples show how small a change in water supply or climate may produce a recognizable and even important change in the economic relations of a people. Lange wrote in 1892, before the climatic studies of the present period had been inaugurated, and he puts forward his explanation modestly, leaving the final solution to others.



FIG. 114—General plan of the fortress of Pucará. The Aguada de Chilcas (p. 312) is in the left center. From Gunardo Lange: *Las ruinas de la fortaleza de Pucará*, in *Anales del Museo de la Plata*, 1892. Scale approximately 1:11,000, reduced from 1:8000.

Such a change in the position of the water supply of a ravine as Lange supposes in explanation of the habitability of El Pucará, is exactly illustrated in the basin of Fiambalá, 200 miles west of this site. Penck has made important studies on the climate and relief of Fiambalá. He finds that the southward-flowing Rio Lajas¹²⁰ at one time reached the town of Tinogasta (Fig. 1), whereas it now ends 5 kilometers (3 miles) farther north, where cultivated lands and a prosperous settlement were developed and were occupied until recent times, when the river ceased to flow beyond a point still farther north, leaving the cultivated lands desolate and the old settlements occupied only by shepherds that now camp there and get water by digging down two or three meters to the underflow.

The case of the Rio Lajas is an illustration of the same principle invoked by Lange. Penck further describes a highly important contrast in the positions of zones of moisture in the basin of Fiambalá in northwestern Argentina (Fig. 87). Summer pasture grows in a belt of mountain slope above 3500 meters, and there those Indians who follow the chase go in search of guanaco and vicuña. There are fresh green grass, springs, and brooks in every valley, in contrast to the great dryness of the basin, or bolsón, of Fiambalá, where cactus and scrub predominate. The valleys are dry; and also in contrast to the relatively wet zone on the mountains is the dry and melancholy puna above the zone of grass in the alpine region. Such a zone of pasture and water supply is dependent upon the presence of a zone of cloud that forms in the high mountains and whose position is determined by the combination of relief and winds already described (p. 273). If such a cloud zone were lowered or raised there would follow a corresponding depression or elevation of the belt of pastures and woodland. Were there to be developed at any period a string of settlements, a civilization, buildings, cultivated lands, these would perforce change their situation to correspond with the change in rainfall and available water supply.

Whether such changes have been brought about in the period of Indian occupation, no one can yet say, but it cannot be too

¹²⁰ Walther Penck: *Der Südrand der Puna de Atacama*, Leipzig, 1920, p. 38.

strongly emphasized that the slight changes in climate and water supply that we have noted have produced such important and clearly defined effects that the greater changes must have produced still greater effects. If such effects were felt during the period of human occupation they would form the objects of one of the most important studies of climate and relief and vegetation on the one hand and of man on the other that the continent of South America affords today. The region is ideally situated for producing such effects and for making the studies just described. In contrast with the climatic belts farther north, which are more sharply defined upon the borders of the mountains and which have a relatively fixed quality, the climatic zones of the border of the Puna de Atacama have a wider range of action. The seasonal extremes are much farther apart here than farther north toward lower latitudes, and the seasonal rainfall is a much more clearly marked thing than in the rest of the Central Andes northward to central Peru. Any disturbance in the level of the climatic zones, in short any change in climate, would be felt over a wider extent of country, over a greater expanse of mountain slope, through a wider range of altitudes.

GLACIAL AND POSTGLACIAL CHANGES OF CLIMATE

Such climatic changes as we have described must not be thought of as purely speculative guesses. Everywhere throughout the Central Andes are the marks of past glaciation which represents a major climatic change of the general type that preceded and followed the Ice Age itself. In 1911 I discovered that glaciers of great length had come down through all the valleys of the high Cordillera Vilcapampa. One of them was at least fifteen miles long. These were the ancestors of glaciers that now inhabit only the heads of the valleys, where they are nourished by a permanent glacial cap of amazing extent and climatic significance in latitude 12° S., almost overlooking the border of the Amazonian plains. I have estimated the height of the snow line of the glacial period to have been 2000 feet lower than the snow line of today. The relationships of the upper and lower limits of the zone of

maximum precipitation on the mountain slopes in the glacial period are illustrated in the diagram, Figure 115. Penck has made similar studies at the southern end of the Puna, where he finds a zone of maximum precipitation whose upper limit at the present time is 4000 meters and whose lower limit is about 3000 meters. Within the upper limit is snowfall in the winter season and occasionally at other times of the year. From the evidence of the carved valley walls and flat floors

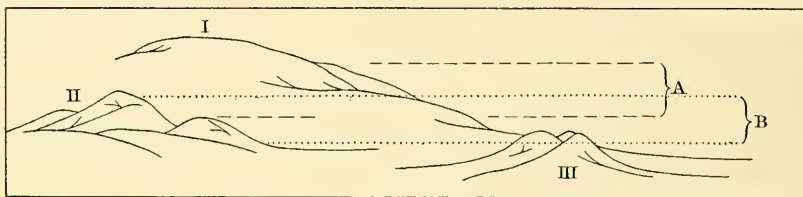


FIG. 115—A represents the upper and lower limits of the zone of maximum precipitation at the present time; B, the limits of Pleistocene time. I, II, and III are mountains of different height and relationship to these two positions of the rainfall belt.

Penck concludes that the present snow line is 600 or 800 meters, that is to say 2000 or 3000 feet, above the snow line of the glacial period.¹²¹ There is snow at 5300 meters on Aconquija; on Tres Cruces in the same latitude (27° S.) in the Western Cordillera the lower limit of permanent snow is at 6300 meters, or a range of 17,000 to 21,000 feet. In southern Peru I found the snow line between 16,000 and 18,000 feet with local variations dependent upon topographic conditions. Where the glaciers of the present time do not descend below 14,000 feet, I found them to have descended to 11,000 feet in the Ice Age. I concluded that the snow line of the glacial period was 1000 meters, or over 3000 feet, lower than now.

The effect of this great change in climate in the glacial period must have been clearly felt upon the well-defined zones of pasture and of woodland or forest on the border of the mountains. This is particularly true in northwestern Argentina, where the belt of woodland is so narrow and patchy that any increase of rainfall through the lowering or raising

¹²¹ Penck, *op. cit.*, pp. 251 *et al.*

of a zone of heavier precipitation must have had the effect of joining up isolated patches of woodland and making continuous forest out of them; or where a diminution of rainfall would have the effect of making the forest growth still more patchy or causing it almost to disappear for a time. The effect upon the grasses of the belt of pastures must be similar. There must have been a thinning out of pastures at the upper limit of the zone of pasture as we see it today and an extension of the pastures at the lower limit of the zone. The increasing cold of the glacial period had the effect of lowering the snow line and the successive climatic zones along with it. The belt of pastures must have been brought down to the summits of mountains that now have no pastures at all of the sort that prevail in the belt of high mountain country of which we speak. Again, there must have been mountains whose summits were covered with pastures before the glacial period and at the present time and that were free from pastures during the glacial period. These circumstances are suggested in Figure 115, the upper and lower levels of the zone of pasture being in critical relation to mountains or mountain ranges, as we may suppose them to be, of three different heights. In addition to the mountain pastures there would be, of course, a wide deployment of the plains pastures to correspond with the wetter climate. In addition to the raising and lowering of the zones of grass and woodland upon the mountain flanks, there would be an absolute increase in grass and woodland on account of this heavier precipitation. The climate of the glacial period was clearly one characterized by more moisture. The ground water and the level of lakes and streams would surely feel the effect of such an increase in available moisture.

VEGETATIONAL CHANGES AS AN INDEX

No one has yet applied to northwestern Argentina the results of field investigations like those made by Clements in our Southwest.¹²² From a comparative study of vegetation

¹²² F. E. Clements: The Original Grassland of Mohave and Colorado Deserts, Report on Investigations in Ecology, *Year Book Carnegie Instn. No. 21 for 1922*, pp. 350-351.

in California and Arizona he finds that the grasslands must once have been continuous across the Mohave and Colorado deserts when they had an annual rainfall of about ten inches in contrast to a rainfall of but two inches a year, as on the floor of the Mohave desert today, or an amount so small as to be incapable of supporting even the most xerophytic of the grasses. He concludes that the region has passed from a condition of mixed prairie at the close of the Pleistocene or Glacial Period to the desert conditions of the present under the pressure of shifting climate. The effect of having the grassland of California in contact with the mixed prairie and the losing of that contact, would be the development of relict groups of grassland in favorable situations though now far removed from similar tracts with which they once enjoyed contact. Our whole thought of these outliers has been that they represented a sort of advance guard, an invasion of the drier area, whereas the more closely analytical field studies have shown that they are *remnants* of a once more extensive grass cover. Migration without the agency of man or water is practically always local, and the wide distribution of these forms of grasses and shrubs requires, as a prerequisite, a natural disturbance or broad climatic change.

Were such studies of grassland and woodland to be carried out in northwestern Argentina, there would be offered a chance to apply the results to the sites of former habitations in the valleys that border the Puna de Atacama. It is not to be supposed that an exact relationship can be established, for the type of culture with which we are dealing was not sufficiently far advanced to permit the drawing of definite conclusions regarding the time of its existence. The point of chief interest would be to discover if the sites selected for habitations were now uninhabitable in fact and not merely inconvenient or difficult to inhabit. That would be the first point. In the second place one should set out to discover if possible what changes in the water supply and in the zones of vegetation would be required to make the sites of former settlement habitable wherever these occur about the borders of the mountain country. If carried out on broad lines over

a wide extent of country, such a study would yield results of first importance both to archeology and to geography, to say nothing of its value to the life of the present population or in the development of the soil and water supply for the greater benefit of future population. Were the times and seasons better known and the value of grassland and woodland really recognized, the life of the region could certainly be better adapted to natural conditions. There is now only a primitive relation of culture on the one hand to geographical conditions on the other. The rainfall and run-off of years of heavy precipitation are allowed to waste themselves in gravelly piedmont slopes and to work destruction upon the cultivated valley lands. The pastures are overgrazed in one part and untouched in another. The waste that has marked the use of water from colonial times still exists.

FORMER DISTRIBUTION OF ALGARROBO FORESTS

It has been argued that certain old maps furnish evidence of past changes of climate, notably in the case of the buried algarrobo forests now exhumed in the Desert of Tarapacá (see p. 16). Such an argument must be taken with great reserve. There are two principal reasons against it. (1) Contemporary evidence of actual forests and a proved knowledge of their extent have yet to be brought forward—the distributions shown on old maps are altogether conjectural and unsupported. (2) It is the habit of piedmont streams like those that descend to the border of the desert of Tarapacá in northern Chile (whence the evidence has come) to shift their courses from side to side; and thus a growth of algarrobo along a given stream channel may be abandoned and left to wither and disappear when the next flood comes down and opens a new channel far to one side. Rainfall so great as to support a *general cover* of algarrobo forest clearly implies a flooding of the salt-covered basin floors of the nitrate desert, the dissolving of the salt deposit itself and overflow to the sea at the lowest places along the Coast Range. A larger number of woodland patches might occur if the rainfall were increased in the mountains alone and

not at all or but very little in the desert, by the process of sub-irrigation. There are today healthy stands of scrub along abandoned watercourses and even in the open piedmont where the distance to ground water is only a few feet. A further slight shift or a *local* diminution of *the drainage discharge* (not a diminished rainfall) would end in the destruction of the growths at these precarious sites. Later floods would then bury the stumps and fallen trunks, and we should have the appearance of a forest lost through climatic change. It is not enough to say that a diminished rainfall would produce like effects. The natural processes operating on a desert piedmont are quite sufficient to produce the visible effects. A new cause need not be sought, and if it is adopted it can only be when contemporary evidence of actual forests of larger size than the local stands of today and of reasonably well known extent, not merely buried fragments, are found. The general theory of climatic change is invitingly simple and spectacular. I believe that such a change must have occurred in the Puna de Atacama and about its borders. But whether the amount of change was sufficiently great in the human period to be determinable today from the scant evidences left behind by earlier folk is a question that can be settled only by further studies in the field.

OTHER ANCIENT HABITATIONS OF THE PUNA

Returning to the Puna region, it has been argued¹²³ that the site of the famous ruin called the Pucará of Rinconada, about 12 miles south of the village of Rinconada (Fig. 87), was occupied by a compact settlement at a time of heavier rainfall, sufficient to water the *andenés*, or cultivated terraces, for these are so situated as to be incapable of irrigation today. The fields and the villages were often far apart, as in the case of the pueblos of Arizona and New Mexico. The cultural elements, which include a remarkable colored fresco, besides grinding stones, hatchets, pottery, arrowheads, and the like, are of a type denoting a substantial settlement, while some

¹²³ Éric Boman: *Antiquités de la région andine de la République Argentine et du Désert d'Atacama*, 2 vols., Paris, 1908; reference in Vol. 2, pp. 632 *et seq.*

of the stone work is distinctive. However, to reach the conclusion that the climate has changed it is necessary to determine by accurate means the actual water resources today, and this has not yet been done.

More circumstantial is the argument in favor of a change of rainfall in the case of the Arroyo de Sayate in the Puna de Jujuy.¹²⁴ The andenes here appear to be arranged in a manner to facilitate irrigation by canals supplied by the Sayate, but no trace of a feeding canal has been found, and it is believed that a canal was never employed. Yet the rainfall today is not sufficient to permit culture without artificial irrigation. Watering by hand does not seem possible, for it would require a population much larger than could be contained in the little ravine in prehistoric times or than is indicated by the number of skeletons in the graves. The traces of water conduits encountered on the terraces of Sayate are interpreted as indicating the practical beginnings of a system of conserving the natural rainfall from terrace to terrace without permitting it to run off violently as it would do if left to take its natural course to the floor of the ravine.

On the other hand, cultivation, plus the greater water-holding capacity of the flat and walled terraces, is enough to account for the conditions described without invoking a change of climate. From the large number of remains of maize in the graves of Sayate it is concluded that maize was the principal food of the valley and that without doubt it was the principal plant cultivated on the terraces, for to find its remains in such great abundance would seem to argue against its being carried by the pre-Spanish Indians from the lower ground in the valleys of Salta and of Jujuy or from the Desert of Atacama. The other food plants that were grown in the Puna in pre-Hispanic times, namely, potatoes, coca, quinoa, and the like, had a secondary importance, and their cultivation was carried on without andenes. Periods of rest of three, four, five, or even seven years between periods of culture, which in turn endure for three or four years at a time, are known to every student of Central Andean culture; and this may well account

¹²⁴ *Ibid.*, Vol. 2, pp. 602 *et seq.*

for the large number of andenes throughout the region without the supposition that the population was at one time vastly greater.

Even if corn were once used in great quantities in the Sayate valley it may have been imported from lower lands. As for the assumption that the andenes were constructed for corn because the other products do not require terraces, this quite overlooks the fact that barley is grown today where it does not ripen—and corn too for that matter—and they are cut green for forage, the seed being brought in from warmer valleys year by year. Green barley is grown in this manner either on andenes or open natural slopes through the higher valleys of almost the whole Central-Andean realm.

ANDENES AS AN EVIDENCE OF FORMER OCCUPATION

The andenes of the Andean region in general have given rise to a great deal of speculation as to possible change of climate. In some places one may see thirty to forty terraces one above another on the longer valley slopes, the lower ten or twelve clearly defined, the rest fading off to narrow bands clearly visible only when the light strikes at the precise angle to bring out their delicate relief. Slopes 1000 to 1200 feet high may be seen covered with these terraces and now wholly abandoned.

The people of Spanish descent refer to the andenes as having been built by "los Gentilares," or Gentiles, as they designate the heathen Indians who lived before the period of the "Christian" Conquest. Naturally so great a development of the andenes suggests a more numerous population. If the few people now living in many a valley were to set about making terraces as extensive as those lying about them, they could not do it in a lifetime.

An excellent example of andenes is seen in the Cayrani valley west of Lake Titicaca. They are not level but slope downhill at gentle gradients. Some are supported by earthen embankments, and others by natural outcrops of rock or of loose stone. There is no finished stonework in evidence. It is not possible to see whether old canals for irrigating the terraces once existed. I could find no evidence of them leading

from the river, but a closer examination might reveal signs of them. Clearly the terracing was not done for the purpose of irrigation, for the terraces run up to the hilltops, where water could not be carried by gravity, and they are to be found also on either side of sharp and deep ravines or high ridges of harder rock.



FIG. 116—Terraced valley slopes in the mountain belt west of Lake Titicaca.

The evidences of past Indian occupation of the *anden*es seems all the more significant because of the established life to which the cultural facts point. In some terraces and burial sites, as, for example, the cemetery on the main trail to Finca Cay-rani, are fragments of worked stone. Slabs of stone were laid across uprights, and in them are large earthen jars with remains of human skeletons barely covered with earth. In several of the jars I found charred cobs without corn upon them, as if the corn had been roasted and eaten off. Little digging has been done in the neighborhood; it is almost un-worked territory. We can be certain that a larger population than now lives in this particular valley once occupied the soil,

but probably no more than could live comfortably if the pastoral resources were used to the fullest extent.

EFFECT OF THE SPANISH CONQUEST ON POPULATION DISTRIBUTION

There may have been a slight change of climate in the past few hundred years or more that led to the abandoning of the terraces in the poorer locations; but, as a whole, this cause has so far not been separable from a much more important one of human origin. In earlier times, when the social structure and business organization of the Indians was in a primitive state, undisturbed by the modern towns and industries of the Spaniard and other foreigners, each region had to produce much the greater part of the food and clothing it required. The history of the organization of the Inca Empire shows a certain degree of communication from place to place, but the means of traffic were so limited that this could hardly have had a thorough-going and intimate effect upon the life of the whole plateau. Granting, however, any degree of communication one may choose to assume within reasonable limits in the pre-Spanish days, it is still true that when the Spaniard came, organized the modern towns, and exerted himself in many instances to gather the Indians into compact communities, there were developed resources and trade currents that changed the old established ways of life. It was one of the great contributions of the white race to Indian economy that difficult sites were made unnecessary. The amount of human labor spent upon stout stone houses on hilltops or steep hill slopes and in getting to them and down again for purposes of the chase or in tilling the valley soil is almost incalculable. When the Spaniard came the intertribal wars diminished and then stopped altogether, and settled life became permanently established in more accessible situations.

The mines called away increasing numbers of Indians from their farms, and the city life also attracted an important Indian population. As the taste for articles of foreign manufacture grew, shops by Indians for the sale of goods to Indians increased

in number. When the development of the rubber forests began there was a sudden demand for labor which could not be supplied from the Indian population of the rubber forests. The whole vast rim of the Amazon basin felt the effects of this call, and the call was one of increasing urgency. The natives of Ceará in easternmost Brazil, many of those in southern Brazil, as well as all the settlements of the Chaco, or grass country, in southeastern Bolivia and northeastern Argentina and the eastern half of the Andean plateau region were affected by it. These are examples of withdrawal of population from farms. Formerly attached to a piece of grazing or farm land, hundreds of thousands now live on work provided by foreign capital and produce or deal in things that are shipped abroad as well as articles or foodstuffs of local consumption. To a notable degree long-established Indian communities became disrupted, and the population was made dependent upon a commercial structure that had its origin in the industrial needs of far-distant peoples in the north temperate zone.

MODERN EXPLOITATION AND ITS EFFECTS

All this meant that there was increasing opportunity for the whites to buy large tracts of land at moderate prices. Estates in southern Peru and in the Bolivian basins and valleys bought for 30,000 soles in a given year increased in value by 30 to 40 per cent by the following year. One proprietor in southern Peru has bought up little by little from the Indians in two adjacent valleys an enormous estate and now owns from 10,000 to 15,000 sheep, 40 horses, and 600 cows. He pastures no alpacas or llamas except by Indians who own them and who work upon his land. To the Indians of the country and of the towns he sells wool and dried mutton. He has engaged as shepherds Indian families who live in isolated huts here and there, each hut surrounded by great corrals in which are herded at night the flocks that in the daytime range far and wide over the adjacent valley lands and mountains and over the terraces all up and down the valley, now entirely uncultivated except for little spots here and there. The extent of the culti-

vated land constitutes but a few per cent of all the terraced areas. The terraces are grown up to ichu grass and the dark *miña* bush used for fuel. In many cases the terraces are either ravined or covered with coarse deposits of alluvial cones or fans. Some are faced with stone where this is abundant, and these endure for a long time. Others are mere earthen embankments with flat tops, and these are more quickly washed down.

The arrangements between proprietor and peon shepherd are as follows. Each month the shepherd obtains one sol, or 50 cents gold, per 100 head of sheep in his care. He also receives half an arroba, or about $12\frac{1}{2}$ pounds, of chuño (dried potatoes), worth about 60 cents gold, half an arroba of quinoa (30 cents gold), a pound of coca (25 cents), and one dried carcass of mutton (50 cents). These items are to be multiplied by the number of hundred head in each shepherd's care, the average running between 500 and 700 sheep. When the shepherd does manual labor upon the estate of the proprietor, that is labor of a general sort—repairing fences or outbuildings, opening ditches, or cultivating land—he obtains coca and food but no pay. The accounts between the proprietor and the shepherd are settled on the first of January of each year. When a shepherd enters the employ of a proprietor he commonly receives 10 sheep to begin with, and these the shepherd may guard with those of the owner or separately, as he may desire. In addition each shepherd has the right to sow grain, plant a garden, and keep cattle. In some cases the shepherds have increased their own flocks up to 200 or more in number. If one of the owner's sheep is lost or killed, the shepherd must lose the amount out of his yearly account. For every ten sheep sheared the shepherd gets 20 cents gold. For slaughtering ten sheep for the market the shepherd gets half of the five following parts: liver, heart, stomach, feet, and pancreas; but he obtains no ordinary meat. He can have the blood of the slaughtered animals if he wishes it.

Under the terms of the arrangement the shepherd must take both meat and wool to the railroad. While in this service he must use his own llamas free of charge, and he obtains in

exchange only food and coca. If the owner has no immediate interest in a given valley, a shepherd in his service may raise llamas there. It is seldom that the shepherd obtains money at the end of the year when the account is settled, generally only a few soles or nothing at all; and some of the shepherds are in debt to the proprietor.

On the Romaña estate (Finca Cayrani) in the Cayrani valley west of Lake Titicaca, to which also the foregoing applies, there are fifteen families of shepherds, and each family consists of about five persons. Before the estate was purchased there were but four or five families in the territory included in it. A first change in the economic system and also in mode of life under the first white governors had brought about the abandonment of the terraces and an actual diminution of the population. The reverse movement is illustrated in this significant example, in which development of the pastoral industry is seen to have brought about an actual increase in population. A further application is considered in the following chapter.

CHAPTER XVII

THE GEOGRAPHICAL SIGNIFICANCE OF THE PUNA

The Puna de Atacama is the greatest barrier within the Central Andes, the most extreme case of lofty, desolate plateau and winter cold. Farther north the high mountain valleys of the Andes are moister and warmer, farther south the mountainous zone is narrower. If the plateau of Bolivia is the widest part of the Andean system it is not the driest nor is it the highest. If the Andes south of the Puna on the border between Chile and Argentina are colder because of a more southerly latitude the zone of cold is narrow, it takes but little time to cross it, it offers little or no foothold for life today, and it offered no scope for civilization in the past. Naturally the effects of the environment upon such inhabitants as there are in the Puna or about its borders and upon the ways of communication are not only marked today but may be traced back by historical and archeological evidence into the racial life and culture of the Indian population.

DO MOUNTAINS DIVIDE OR UNITE PEOPLES?

We often think of mountains as tending to divide peoples. We picture their height, their rigorous climate, their intricate system of roads, the steep ascents and descents, as barriers to free intercourse. There abound specific and accurate illustrations of this principle, but we must also carry in mind an opposite effect, namely, that mountains in some cases tend to hold people together. In fact, one must go further and recognize that part of the population of a given region may exhibit one of these two responses while part of the population in the same region at the same time may exhibit the opposite response.

Let us take minerals by way of illustration. In the Central Andes there are a number of famous mineral localities, such as Potosí, Corocoro, and, farther south, in the Puna de Atacama, the less famous but rather widely known San Antonio de los Cobres. There are many mineral localities in the Desert of

Atacama and in the region of Copiapó in Chile that might also be cited. All of these places are served by railroads that reach or nearly reach the mines. These railroads are built at great expense, operated on a very costly basis with coal imported from overseas, and traffic is so light that new sources of freight are a constant anxiety of the traffic manager. When we went to the superintendent of one of the railroads to ask him for the favor of free transportation because we were a scientific expedition he replied that he would willingly give us passes for ourselves but that he should have to charge us for the freight because every additional pound loaded onto the freight train definitely raised his costs on account of the high price of imported coal. Under these circumstances a gradient is not a barrier in the sense that cars may not pass, but it is truly a barrier in the sense that every additional mile of ascent increases by so much more the operating charges. We may say that man has overcome the mountain in such a case but that he pays a price. The mountain exacts a toll from him that must be added to the other charges of his business. It is natural for him to wish the mountain away. It is also natural that his railway net should be spread out in such a way as to be most favorably located with reference to the sources of his freight, the large towns that may furnish a tributary tonnage, and in sympathy with the main lines of the topographical relief. Figure 1 shows the railway net of the Central Andes, and it is the most striking feature of the map that the railways come up to the border of the mountains but that only two penetrate them. Railway projects are divided in consequence of the broken and lofty mountain barrier.

How strikingly different is the effect of high mountain country upon the life of mountain peoples! I have elsewhere brought out this fact for the region of southern Peru and western Bolivia.¹²⁵ The mountain is not a barrier to shepherds who drive their flocks all over the higher pastures clear to the snow line. It is not a barrier to the same shepherds when they go up

¹²⁵ Isaiah Bowman: *The Highland Dweller of Bolivia: An Anthropogeographic Interpretation* *Bull. Geogr. Soc. of Philadelphia*, Vol. 7, 1909, pp. 159-184.

Idem; *The Andes of Southern Peru*, New York, 1916.

and down the mountain valleys to exchange their pastoral products, such as hides, wool, and the like, for what the town can furnish in the way of necessary implements or cloth. A man born at an altitude of 12,000 feet who is accustomed from childhood to steep mountain ascents and who knows no other environment cannot possibly look upon the greater part of his region as a barrier. To him it is all the world there is, and it is good. If, as happens in the Central Andes, all the peoples he comes in contact with are of like nature, follow the same occupations, live in the same type of house, make their living in the same way, his exchanges with them and all his knowledge lead him to look upon a high plateau and high mountain valley as the natural home of man. Because the mountain zone is broad in Peru and Bolivia, there was scope for the development of an extensive civilization. We find much the same type of life among the primitive inhabitants from the top of the woodland zone on the east to the desert zone on the west. Were that zone narrow, the population upon one side would have little influence on that of the other and indeed might have been drawn off to lower elevations. As it is, they have developed a distinctive civilization which we may say has been held together and has developed in part because of the very breadth and height of the zone.

Farther south the Puna de Atacama has such rigorous climatic conditions that the population is forcibly excluded every winter. Yet in spite of this exclusion there is a bond between the populations on the two sides, and it has existed down to this day by reason of the fact that the country was settled by pioneers from the north and west. We need to correct the common view that mountains perforce exercise a dividing influence, for an opposite conclusion is drawn from a study of many fields besides the Central Andes. In the Pyrenees, the people living in different valleys frequently made agreements regarding pasture rights and the dues to be paid by their respective flocks while on their annual migrations. From the thirteenth century down to the eighteenth there are many evidences of the unifying influence of these mountain valleys upon the people inhabiting them. Favoring

migration and unity is the prevailing north-and-south trend of the Pyrenean valleys which encouraged communication between France and Spain and thus gave the mountain zone itself, for the pasture and for the food it contained, an importance not merely local or regional in character.¹²⁶ It is only in our time, with through transportation in mind, that the Pyrenees have been looked upon as a barrier. In short, what is a home for the simpler civilization of yesterday may be a barrier for the highly developed civilization of today, which requires organization, government, transportation, access to world markets in a way and on a scale unknown to the primitive possessor of the soil.

OCCUPATION OF THE LAND

The Puna de Atacama gains in geographical importance to the degree that it is studied as a part of the whole belt of high country that runs southward along the Andean Cordillera through Peru, Bolivia, and northern Chile. The mountain folk of this region live under unlike conditions of climate, relief, trails, and markets; but all are alike in working at amazingly great altitudes and under primitive conditions that call always for intelligent and often for painstaking adaptation. The physical differences which the high country displays from place to place are reflected in the life and welfare of the various Indian communities. To conclude this chapter we shall now explore the conditions in certain more northerly districts in order the better to see the operation of physical handicaps that grow gradually more difficult in a southerly direction until they reach their climax in the bleak, cold, and arid Puna de Atacama where even the shepherds are driven out in winter at altitudes at which agriculture and cities flourish in Bolivia and central and southern Peru.

In Peru and Bolivia as far south as Uyuni (latitude 20° S.) the plateau and valley country between the eastern and western cordilleras has sufficient rain to make possible the cultivation of alluvial and hillside soils without irrigation, though irrigation is practiced throughout the whole of the

¹²⁶ Julius Klein: *The Mesta: A Study in Spanish Economic History, 1273-1836* (Harvard Economic Studies, Vol. 21), Cambridge, Mass., 1920.

mountain belt in which cereals are grown; that is up to elevations of 11,000 to 12,000 feet. The surface of the high Central Andean plateau may be seen at its best between Lake Titicaca and La Paz. Barley, wheat, and millet are raised; and the small native potato grows above the zone of irrigation up to very high levels, only a thousand feet below the snow line. Naturally the location of settlements as well as the houses of individual farmers is determined by access to water for irrigation. This is true for the terraces and valley floors of deep-sunk canyons like those of the Cotahuasi and the Apurimac in central Peru and the great plantations around Abancay. In all the deeper basins and valleys there is dependence for cereals, fruit orchards, and corn and cane fields upon an assured source of water.

Least dependent upon the water supply are the small settlements and individual farms which rely upon flocks and herds for a livelihood and supplement such resources by growing potatoes in favorable sites. Such communities and individuals depend for part of their livelihood, as a rule, upon services to plantation owners. Even the lands they occupy are normally rented from the large *hacendados* upon the valley floor where the main settlements and the distillation works for producing brandy are located. The rent is paid in labor in such instances, sometimes supplemented by a very small money payment.

The very existence of the system of land tenure that prevails in these two countries and that brings into vital relation the dweller in the high mountain valleys and the owner of the valley floor and the town upon it is an indication of the thorough *usefulness* of the land in the Central Andes north of the Puna de Atacama throughout the entire belt from deep-cut canyon up over terraces and intermediate slopes, high basins, and still higher pastures, to the snow line. There may be bouldery tracts here and there, expanses of bare rock, *arenales* or local sandy wastes, poorly drained, brackish or saline swamps, steep canyon borders, and coarse, stony land waste at the head of an alluvial fan where both soil and a convenient water supply are lacking—but these are all local exceptions. The amount of land that is necessary to support a community

of a given size varies from place to place according to the richness of the pastures, the degree of dissection of the relief, the access to water supply, and the distance from consuming centers and the railway. Yet still the generalization holds true that, speaking roughly, all of the land is useful.



FIG. 117—The high plateau, or altiplano, of Bolivia between Lake Titicaca and La Paz, looking eastward from a point near Viacha toward the Cordillera Real. The whole plain is intensively cultivated except where it is too gravelly or stony in belts and patches near the mountains.

On the east is the tropical forest, and on the west of the Peruvian and Bolivian cordilleras is the coastal desert; and in both these environments the usefulness of the land and the disposition of the settlements are in marked contrast to the conditions we have sketched above. The forest has natural pathways in the rivers that thread it, the so-called "flowing roads," so that men are driven to seek favorable settlements upon the river border. Strikingly similar are the disposition of settlements in the desert, where men seek the river though the interfluves are open, for the latter are dry and are areas of transit, not sources of livelihood, and it is on the valley floor

and the bordering terraces that man is able to satisfy his material needs.

CONTRASTS BETWEEN NORTHERN AND SOUTHERN SECTIONS OF THE CENTRAL ANDES

Central-western Bolivia marks the change between the northern portion of the Central Andes and that southern portion that embraces the great salars and interior basins that form the characteristic feature of the Puna landscape. The change is interestingly foreshadowed in the contrast between lakes Titicaca and Poopó. While the water of Lake Titicaca is slightly brackish, fish live in it and are caught for food; and its border is in many places fringed with reeds that grow in shallow water. The great depression in which the lake lies is fed by rains and melting snows from the surrounding highlands and mountains, principally the Cordillera Real; and so copious and regular is the supply that, instead of drying up, Lake Titicaca persists as a large lake and continuously overflows its southern rim into the vast depression just south of it. The outlet of Lake Titicaca, the Desaguadero, pursues its course southeastward to Lake Poopó, more than 400 feet lower than Lake Titicaca. Though Lake Poopó spills a moderate amount of water westward into the great salars of Coipasa, there is so much water evaporated from the shallow basin of Poopó as to render the water too salt to be drinkable.

These changes in salinity of the water in the three successive basins arranged from north to south—Titicaca, Poopó, and Coipasa—are in almost exact sympathy with the rainfall, and as the rainfall diminishes we find man himself making corresponding responses. Cultivation, or at least occupation for pasture, extends pretty much over the whole surface of the mountain and valley zone of Peru, as we have seen above; and the same is true of the Bolivian plateau south of Lake Titicaca. Midway between the two lakes a change takes place. The land adjacent to Titicaca is cultivated for cereals, the soil farther south becomes more sterile, and saline tracts more numerous. The effect is to divide the population into two ribbons (east and west of the Salar de Uyuni) instead of a continuous broad

band (Desaguadero Valley). In just the proportion that they become divided does the character of the settlements change. Where it is a continuous belt there is more frequent communication and larger towns. Farther south the settlements in the central part of the basin become small and widely scattered.

The salars themselves have no towns upon them because they are quite uninhabitable owing to the absence of fresh water and pasture and the very strong contrasts of temperature from night to day, the heat of midday being unbearable for practically the whole of the year and the sunlight extremely trying. In addition, Lake Poopó is almost surrounded by a saline marsh. South of Coipasa is the great Salar de Uyuni. It fills almost the entire width of the great table-land between the interior borders of the eastern and western cordilleras. South of it the salars are broken up into smaller units by local volcanic eruptions.

Thence southward the salars continue over a broad stretch of country (see the map, Fig. 87) occupying a portion of eastern Chile southeast of Calama, southwestern Bolivia, and northwestern Argentina.¹²⁷

With diminishing rainfall southward the size of the salars diminishes, for we can only have the greatest salars where we have relatively flat topography, broad basin floors upon which the waters may be spread out in a thin sheet, and a substantial amount of rain. If the rainfall becomes very light the salars will be broken up into small units in the hollows of limited basin floors, and this is the situation southward in the Puna de Atacama.

The contrast between the Puna de Atacama and the plateaus of Bolivia and Peru is still stronger if we study them with respect to their eastern approaches and the coming and going

¹²⁷ The details of relief and drainage are shown in the clearest manner upon three adjacent sheets of the Millionth Map of Hispanic America by the American Geographical Society. The first-named is published. The other two will appear in 1925. They are in order from north to south: the La Paz sheet, the Iquique sheet, and the Atacama sheet. The boundary surveys between the three countries, Chile, Bolivia, and Argentina, whose common frontiers unite in the Puna de Atacama on the 23rd parallel of latitude south, have provided the major part of the cartographic material gathered together and analyzed in the production of the two latter sheets.

of trader and settler between the high country and the low country. The eastern slopes of the Andes in Peru and Bolivia are wet and forested. Indeed, so heavy is the rainfall that the valley floors are in places swampy; and some situations are unhealthful owing to stagnant or semistagnant drainage as, for example, a portion of the Yungas. Thus it appears that in spite of its subtropical character, its undoubted productivity, and the great demand for its products on the plateau, the eastern slope region labors under a physical handicap that has not been removed down to our own time. Moreover, the eastern slopes of the Andes in Peru and Bolivia lie in situations far inland. Eastward, several thousand miles of distance separate them from the Atlantic, and there are no great settlements calling to them for the products of forest and field. Their markets are overseas, and in addition to the ocean distances are the difficulties of the river passage. Their geographical position has resulted in settlement and trade as a consequence of stimuli that have issued *from the mountain zone*; and it is the mountain zone to which they send their products and in which they must find their coastal outlets. Though the improvement of navigation and the building of railroad lines in the Amazon country have been regularly forecast for sixty years, the only railroad is the Madeira-Mamoré line and the transportation service of the streams is still confined to the small launch and the canoe.

In much the same way the Puna de Atacama, the altiplano of western Bolivia, and the high basins of Peru were long tied to the Pacific; and that indeed is the situation of the two last-named regions today. By contrast the population of the valleys on the eastern border of the Puna de Atacama have now established relations with larger settlements east of the mountains, like Salta, Tucumán, Andalgalá, Tinogasta, and this to such a degree that their trade is definitely oriented toward the southeast. While the connections with the Pacific are by no means broken, they are of less importance on the whole than they were in the centuries of colonial trade. In short, the plain draws the mountain life down to it, whereas in Bolivia and Peru it is the mountain toward which gravitates the life of the eastern valleys and the bordering plain.

The width of the forest belt is also a matter of great importance, for in eastern Peru and Bolivia the forest is broad and the growth dense. As we go southward the forest becomes more patchy in character. It narrows down to a well-defined band on the mountain side that can sometimes be seen in its whole breadth from a single viewpoint. There are gaps or "passes" through it. Transit up and down the mountain valleys through the forest zone is here unhindered by the growth of jungle or dense stands of trees. Though there is a wet season it is of short duration, and the floods in the rivers have less force. The trails are easier to maintain. Trade is more regular. The distances to be covered may be as great as farther north, but the time of passage is shorter. It is easy to think that under these conditions the effect of the plain upon the mountain population of the Puna in drawing it away from its Pacific outlets is obvious; but the obviousness disappears when we see that, in spite of the far greater difficulties of the passage in eastern Peru and Bolivia and in spite of the inviting rivers that flow down into the Amazon basin, the mountain continues to attract the trade of the eastern valleys and the bordering plain.

In the eastern mountain belt of Peru and Bolivia there is a permanent gap of several thousand feet vertical elevation between the zone of snow and the zone of forest. The belt of maximum rainfall lies between 5000 and 8000 feet. The cold timber line runs from 9000 to 10,500 feet, with a few outleirs of stunted woodland as far as 12,500 feet. In secluded valleys deep set among the eastern mountains a dry timber line occurs in places around 3000 feet with many variations in elevation due to the variable declivity, the exposure of the slopes, and the degree of seclusion of the valleys.¹²⁸ So we find permanent habitations but little below the snow line and a group of distinctive high mountain folk widely distributed throughout the pasture belt. If the alpine meadows of these mountains are

¹²⁸ A systematic description of the plant geography of Bolivia and southern Peru is given by Th. Herzog: *Die Pflanzenwelt der bolivischen Anden und ihres östlichen Vorlandes*, in *Die Vegetation der Erde*, 1923. Besides the botanical descriptions there are photographs and two valuable maps of the Eastern Cordillera of Bolivia and of Bolivia as a whole.

buried under snow or troubled with hail it is on their upper fringe only, for elsewhere the snowfall is so light that an hour of morning sunshine dissipates it. Virtually the whole of the pasture belt is open for stock the year round.

In southern Peru, along the 73rd meridian, I passed a permanent habitation at 17,100 feet, or only a little below the snow line, believed to be the highest permanent habitation yet found anywhere in the world. Hundreds of alpacas and sheep grazed on the hill slopes and valley floors roundabout; and their tracks showed plainly that they were frequently driven up to the snow line in those valleys, where a trickle of water supports a band of pasture. Less than 100 feet below them were other huts and flocks. The situation illustrates the extent to which the high pastures may be utilized. High valleys at 16,000 feet are frequent in which a thick carpet of grass supports large flocks of sheep, llamas, and alpacas; and the valley floor is the site of numerous huts and corrals.¹²⁹

By contrast, the highest permanent habitations above Poma in the region of Peñas Blancas were at 11,000 feet. No permanent settlements aside from individual huts or shelters can be found at higher elevations, and no towns at all. The hamlets or villages mentioned in Chapter XV are all below 12,000 feet. No town of real consequence and, with the exception of San Antonio de los Cobres, none at all with a population exceeding 500 lies above 10,000 feet. No town of more than 1000 lies above the forest zone. To find towns of this size we must go into the forest belt or immediately below it. Such, for example, is the situation of Salta, Jujuy, Tucumán, Catamarca, as well as a host of lesser towns among or near them. All the settlements are closely associated with the *eastern* slopes rather than the Puna or the coastal desert. That is, *instead of avoiding the rainy belt as in Peru and northeastern Bolivia the population seeks it on the border of the Puna.*

EXPLOITATION OF THE PASTURES

There is no present prospect of the development of minerals in the Puna de Atacama on such a scale as to support a large

¹²⁹ Isaiah Bowman: *Andes of Southern Peru*, pp. 52-53 *et al.*

settlement. Nor is there a sufficient water supply concentrated at any point to tempt a considerable agricultural population. Development of the pasture land is the only known way of increasing the population and production. When we consider the small forage resources of the Puna and its bordering valleys at the present time it might seem to be a matter of small importance to the world that the pastures are capable of improved use; but to take this view is to overlook the growing importance of pasture to the world as a whole. In the pioneering belt of the world the shepherd has everywhere retreated before the farmer.

With every advance in settlement at the expense of the open range, man has been driven to explore the limit of possibilities in pasturage. The example of Australia is interesting in this respect. The natural ranges have given way to wheat farms over large territories, and the inner ranges and plateaus have been explored with the result that some of them have been found to have highly important pasture land which needs only a supply of drinking water from artesian wells to make them of use to the rancher. South Africa has had similar experience, and government aid in the drilling of wells has become a part of government policy.

Every advance into the range country has meant larger cities and denser communities outside the range and an increase in the demand for leather and leather products as well as for wool and meat. During the past one hundred and fifty years, that is to say during the modern industrial period, the population of the world has doubled, and almost everywhere city populations have had an abnormal increase. This means that there must be a diminished use of the products of the range, particularly meat and skins, or utilization of ranges hitherto neglected, or an increase in the number of expensive stall-fed cattle. These aspects of the case lend peculiar interest to the pastures of the Andes. Throughout their extent they are undeveloped except near the larger towns and mining centers or along the routes of rail or pack-train transportation. Yet little effort has been made by any of the governments to turn this resource to account. The Bolivian government is re-

ported to have experimented with Siberian grasses in the hope of finding hardy drought- and cold-resisting varieties in distant parts of the world that will endure the climate of high elevations in the Andes and furnish additional forage. The search should be pursued through government agencies in a much more earnest fashion than has been the case up to this time, for our experience in the search of agricultural plants in the United States raises the presumption that a similar exploration for grasses would lead to a far better adjustment of forage plants to new situations.

Were such means employed to increase the forage resources of the Puna and its larger basins and valleys it would make possible the better use of certain pastures that are now hardly used at all. In every period of wet years there is a vast increase of forage afield. The more favorable slopes have uncounted acres of forage which is wasted, because it is only the *minimum* capacity of the land that now forms the standard of size of flocks and herds grazing in the mountains. Before herds can be assembled from a distance to take advantage of short-lived wet-season pastures the dry years have come again.

THE ALPACA PASTURES OF NORTHERN BOLIVIA

The value of pasture land in the special economy of the Central Andes is illustrated by the experience of Bolivians in the alpaca pastures at high elevations north of Lake Titicaca in the Nevados de Apolobamba.¹³⁰ Alpaca wool, which is very fine and long, is best grown from flocks that graze in short, rather thick pastures where there is fairly abundant water supply but especially where the elevation is sufficiently great

¹³⁰ The pastures of Apolobamba lie in a region long in dispute between Bolivia and Peru. Though a boundary settlement was made on the basis of an arbitral award in 1908, the country in dispute was the scene of many quarrels between individual alpaca owners and landowners of Peru on the one side, and Bolivia on the other. As a result of continuing quarrels, thefts, and outrages, the number of alpacas was reduced from 200,000 to 60,000 on the Bolivian side. Wool was smuggled across the frontier from Bolivia to Peru whence it was taken to Arequipa and sold in Europe as Arequipa alpaca. The boundary difficulty embarrassed Bolivia because its officially recognized exports of alpaca wool fell off and it lost in customs receipts. It also lost in financial prestige, for alpaca wool is one of its *distinctive* exports upon which it depends to keep up its income as well as to stabilize its international exchanges.

to give an almost continuously cool or cold climate the year round—in the Central Andes above 15,000 feet. In such combinations of climate and pasture the finest wools are grown, but such combinations occur only at elevations one or two thousand feet below the snow line and far above the limit at which white populations can live permanently in large numbers.

The Bolivian government has attempted to build up the alpaca business in the Apolobamba region by selling a monopoly of the wool industry. The concessionaire is the only person in the district who can take the property and animals of the Indian if the latter does not meet his contractual obligation to deliver a certain amount of wool. It works out that the concessionaire is enabled to stock his several ranches with the beasts of defaulting creditors. The concessionaire keeps a store and has a monopoly of the trade in alcohol in his district, his place of business being the port of entry, Puerto Acosto, or Huaicho, as it used to be called. To obtain the wool he signs a contract with an Indian who is to deliver an agreed amount, say five pounds per head from a flock of two hundred, or a thousand pounds in all. This contract is signed by the *corregidor*, or subprefect, and stamped with a seal. The Indian obtains advances on his contract from the concessionaire. These consist of clothing and food, for in the best alpaca districts no vegetable food at all can be raised, not even potatoes. Supplies consist of chuño, quinoa, barley, wheat, corn, etc. The concessionaire agrees with the government in return for rights of ownership to four square leagues of land to stock it with 2500 model alpacas in three years. In return for this he obtains permanent title to the land at the end of three years. All that he produces or obtains from the Indians he ships out of Bolivia as Bolivian wool to Europe, and unlike other exporters he pays no export duty for twenty years. The government aids the enterprise further by laying no duty on wool going out of Puerto Acosta but requiring a heavy duty to be paid on wool leaving Cojata, a town of a thousand or more on the frontier where the alpaca is produced. By arrangement between the two governments, Bolivian wool destined for overseas consumption pays no duty on transit across southern Peru

and in the Peruvian ports of Puno on Lake Titicaca and Mollendo on the Pacific.

POSSIBLE DEVELOPMENT IN THE PUNA DE ATACAMA

Though there is no corresponding prospect of the development of alpaca pastures in the Puna, it would be possible to extend the range of llamas and sheep at intermediate levels below the drier tracts or on their borders where a better type of grass may eventually be introduced. The time will surely come when the occupation of the cattle-farming and grazing lands of the Argentine will have been completed, and these vast tracts of little-used mountain pastures will then become a positive asset. The process is even now going on and is illustrated by the figures of land values given on page 210, land having increased in value in the Calchaquí valley several hundred per cent in a decade through the increasing use of pasture lands. The government must take the lead. The sinking of wells, the recovery or storage of water, and the improvement of the pasture flora is beyond the capacity of the individual, who cannot turn it into immediate account in his day and generation, partly because of the large capital investment, partly because of the length of time over which the experiment must run.

At best the Puna and its bordering valleys will be a country of relatively thin population for all time. Should the nitrate deposits decline in importance on account of the development of synthetic nitrate processes in the temperate zone near the seats of industry where water power is available in large amounts (compare p. 87), the pastoral villages of the Puna and its borders would for a time also decline. Of borax development there may be some in time, but borax is not a rare mineral. There is only a remote chance of some development taking place through minerals yet to be discovered, for as a whole the Puna is a region of volcanic rock of a type in which mineral deposits of commercial value are not found.

CHAPTER XVIII

THE HISTORICAL BEARING

The contemporary life of any region is not a main object of study by the geographer alone; the record of it is of high value to the historian, who is thereby put in possession of far better material for an analysis of the life of the past. In the unfolding of civilization in the great cultural centers of the world there were an almost infinite number of stages and of types of environment. The effect of physical conditions was now moderate, now great. To estimate such an effect requires the handling of geographical materials, and it still remains a fact that the accepted technique of historical research lays far too little stress upon geographical sources and particularly upon geographical method. The definitive history of South America will be written by that historian who knows best the geography of South America today, for in the present life in one place or another one may find illustrated virtually every stage that has passed. More than that, there is value in studying every important response to environment, no matter in what part of the world it may be displayed; for the flow of knowledge of plant life and of human organization tends in time to put new tools into the hands of men struggling against conditions whose conquest or amelioration has already been achieved elsewhere. This makes life not merely easier and happier here and there as adaptation is carried forward more rapidly; it makes it also more intelligent and conscious and thereby sets up all manner of secondary impulses that speed the progress of mankind.

The Desert of Atacama and the Puna de Atacama fall within one of the seven great regions of the world in which the population density is less than one inhabitant per square mile. Yet their effect upon life both settled and transient is an outstanding, indeed a vital, fact in the history and social development of South America. Through their arid wastes streamed

the Inca armies before the Conquest; and after that came the Spanish adventurers and soldiers of fortune, the founders of cities, the administrators, round whom gathered bands of determined men, those that drifted thither and those that came as sturdy settlers to establish families in the New World. At first these were all tied to Spain, to the Indies, to the great trading companies. It was long before they became measurably self-sufficient. To the degree to which they spread out along lines of natural development—used the best lands known or accessible to them, kept their connections with the sea carriers, sought out new and distinctive sources of revenue—to this degree they grew prosperous, substantial. It is a striking fact of history that Atacama, extending right along the coast for nine hundred miles, should yet have been crossed by trails and dotted with towns most of which have kept their pioneer quality through four centuries of time. The present outposts of trade, of social life, of Indian settlement furnish a picture of pioneer life as marked as it is persistent. A provincial social structure and primitive means of transport in widely spaced communities, these basic conditions have made the region a geographical laboratory where life flows on in accustomed channels except where locally turned aside by the arrival of the revolutionizing railway or the opening of a mine. The more striking and significant are these forms of life by reason of the strong contrasts they exhibit to the industrial life of the great mining centers of today like Chuquicamata or to the nitrate desert whither for more than half a century have come the ships of every industrial nation in the world and over which was fought a bitter and disastrous war.

The Atacama region—for the most part a thinly populated desert—is significant in a still larger sense. In its geographic and historic effects it is not an isolated example but rather belongs to a class of natural regions that have helped to fashion the history of the entire Hispanic-American realm. In colonial times there were only a few centers of power in South America, and these were at great distances from one another. The obstructions and impediments of nature tended to throw the

greater communities into certain natural groups whence arose regional consciousness and, almost of necessity, a name, a capital, a flag, international boundaries, sentiment for a national life and the traditions that logically follow, worship of revolutionary heroes, the machinery of government. The physical geography was unfavorable to that broad and sweeping occupation of the greater part of the continent by a people disposed to try to agree upon common principles as in the United States. The Desert of Atacama effectively separated the settlements of Peru and Chile until national traditions had become fixed and glorified in the local history and literature. Similarly divided were the settlements of Chile and Argentina, less by the great mountain wall between them than by the arid country east of the mountains and the sheer space to be overcome in reaching the settlements of the Plata long confined to the coastal region. The rubber-yielding Amazon country was long curiously like the Desert of Atacama in its gravitative pull upon outside industrial countries of the temperate zone while yet acting as a vast barrier to international communication. There was no concentration of wealth, as in the case of Java and Ceylon with their modern rubber plantations. Except for widely extended traffic by canoe and launch on the part of notoriously migratory, unstable, and limited groups of whites supplemented by a thin native population this vast forest had every quality of a barrier and none of those of a connecting zone despite its naturally available fluvial system. It has remained a great belt of division between Colombia, Venezuela, and the Guianas on the north and Peru, Bolivia, Paraguay, and parts of Brazil on the south.

Even with a limited territory to govern, it has been hard to maintain political unity. The natural layout of fertile plains, basins, valleys, mountain ranges, streams, and trails, separates the people of a given country into small units. Bolivia and Peru both illustrate this condition and effect. There are four centers of gravitation in Bolivia—La Paz, Oruro, Sucre, and Cochabamba—and each had its strongly independent local life and only a limited effect upon the other centers. Mere distance, to be traversed only by primitive means in the

case of all four until less than a score of years ago, was a prime consideration. Each town is measurably self-contained with adequate agricultural tracts tributary to it. Each is in a state of culture that leads it to look outside rather than to a neighboring center for the imports it desires to obtain. This self-sufficiency is no less true in a political or a social sense than in a business one. The intermarriage of prominent and influential families is a natural consequence of the lack of social communication with the world outside the town or the valley or the region. Having a large native Indian population that furnished a labor substratum, a fairly well balanced and satisfactory life had been developed that increased the independence which a pioneer condition had fixed in the character of the people. Since the beginning of Bolivian history there has been a marked rivalry between the four principal towns to influence government and to maintain an autonomous condition.

In Peru revolutions have frequently started in Arequipa, Abancay, Cuzco, and elsewhere in the interior where a high degree of self-sufficiency and a regional consciousness and family interrelationships have worked powerfully through successive generations. Early in 1911 Cuzco and Abancay were both the scene of revolutionary fighting, and the latter city was besieged until government forces succeeded in capturing the principal body of insurgents. I had one of them as a guide during a part of my journey across the Western Cordillera of Peru in that year and from him learned many interesting things regarding the point of view of the insurgents, the history of the fighting, and his own detention in a government prison at Arequipa from which he had escaped but a short time before. It was not merely grievances against the government, it was also the fact that they were young men in search of adventure that welded the band together and led to military resistance against the powers that were. In the house of the Prefect of the Department of Abancay, Señor Gonzales showed me how he managed the affairs of his department and, pointing to the telegraph instrument and to a group of his soldiers outside, told me that there were the two chief means of govern-

ment in his country and they would continue to be the means until some future day when railway lines, a better government, the fuller exploitation of Peruvian resources, and the general education of his people had risen to the point where a solid nation could be developed and its unity assured.

We commonly think of battles as the conflict of armies merely, instead of realizing that they represent also the conflict of ideas and of environments. Every group of people that has been organized in an environment that isolates them measurably from the rest of the country has certain local and immediate needs which it can satisfy, and it has certain outside needs which can only be satisfied by a central government, either because they call for an outlay of capital upon a scale larger than the local group can obtain or because other groups are involved whose needs must also be taken into account. These outside needs that can be satisfied by government only furnish the chief source of dissatisfaction in every loosely organized society spread out and scattered over an undeveloped country. To the man at Abancay government may mean just one thing—the source of power that can build a railroad to furnish him an outlet for his sugar and brandy to the markets of the coast and the streams of ocean commerce. When government does not give him this one thing, he thinks it a very poor affair; and when he revolts, it is not to carry out some well-thought-out or lofty or cherished plan of his own but simply to protest against the failure of the government to give him the one thing that he asks and that seems so easy for it to grant.

It is no light task to get such a man to understand that the very conditions that have led to his kind of logic prevent the central government, even with the best of intentions and the most intelligent direction of affairs, from accomplishing very much in a few years. The handicaps are too great; for above and beyond the scattered nature of the settlements, the towns, the mines, the ports, the railways, the isolated basins and valleys, the dividing influence of the relief and the climate of the plateaus and mountain ranges is largely responsible for the provincial points of view of the leaders in the several scattered

communities. If you were to point this out to the leaders of an isolated community they would be quick to deny the influence thus alleged. To them the ambitions of a powerful politician, the corruption of the central government, the ignorance of the masses, and the greedy nature of the exploiting foreigner are the first causes of disorganization and complaint. While these are the immediate agencies that affect his life and welfare, they are not the ultimate and basic factors in it. The isolated community never sees itself molded by its environment. It looks outside for the source of its troubles.

In considering the effect of physical geography upon life it is not to be supposed that we are talking of barriers that keep people physically apart; as we have already said, it is a question of the effort that has to be expended to pass obstacles. Even passable mountain barriers exact a toll. They tend to increase the degree of separation of peoples naturally separated by earlier traditions, by the location of their chief commercial outlets, by the association of each with a regional environment that has become fixed in history and in national consciousness. The Atacama country, by changes in political ownership, by the war fought over it, by the persistent pioneer quality of its settlements, by the distinctive and strongly individualized quality of its native life, powerfully illuminates the history and geography of South America. It reveals the mode by which the effects of physical circumstance were combined with racial traits to produce not a single great nation, as in the case of the United States, but instead a number of nations, small in population and cultural elements if not in area, and insecure. Of each it could be said that its existence was dependent upon a vigorous "regionalism," strongly embedded in the racial memory in the homelands of Spain and Portugal and strongly developed in its new environment, where the race in its settled stage seemed long overcome by the magnitude of the physical barriers raised on every side despite the heroic work of the first explorers and founders like Pizarro and Orellano and Aguirre and a host of others whose historical stature can never overmatch their achievements.

INDEX

- Abancay, 346
 Abaroa Brothers, 234
 Acay, 202, 207
 Aconcagua, 252
 Aconquija, 316
 Adams, G. I., 90
 Adobe houses, 144
 Africa, water supply, 130
 Agassiz, Louis, 1
 Agriculture, 49; experiments, 70; rain-fall in relation to, 49; withdrawal from, 325
 Agua Amarga, 169
 Aguada de Chilcas, 312, 313
 Aguadas, 265
 Aguadas Dulces, 172
 Aguas Blancas, 242, 247; winter camp of shepherds, 243 (ill.)
 Aguas Calientes, 281, 283 (ill.)
 Aguirre, Camilo, 102
 Aguirre, Francisco de, 101, 104
 Aguirre, Hernando de, 163
 Ahlmann, H. W., 111
 Aillo, 241
 Albert, Federico, 139, 142
 Alcohol, 28, 341
 Alfalfa, 118, 119, 208, 240; Argentina, 192; cultivation, 134; hauling at Vallenar, 135 (ill.); pastures, 37 (ill.)
 Alfalfa meadows, 133; irrigation, 134; Poma, 202; Vallenar, 133
 Algarroba fruit, 242
 Algarrobal, 36, 69
 Algarrobal River, 114
 Algarrobales, 16
 Algarrobilla, 137, 138, 139; pod and seeds, 139 (ill.)
 Algarrobo, 12, 18; dead forests, 16; drink made from the beans, 226; forests, former distribution, 319; tree, 66 (ill.)
 Algeria, water measurement, 130
 Alianza, 18, 36
 Almagro, Diego de, 84, 85, 102, 201
 Almeida, Diego de, 174
 Alpaca, 308; pastures in Bolivia, 340; wool, 340, 341
 Altiplano, 193, 215; cultivation, 332, 333 (ill.)
 Altitude, effects on man, 24, 29, 38, 281, 294
 Alvarez, Arturo, 234, 242
 Amazon Basin, 325, 336, 337, 345
 Ambrosetti, J. B., 281
 Ancon, Treaty of, 83, 297
 Andalgalá, 186, 250, 289; Pucará, 311
 Andean desert, 7
 Andenes, 320, 321; as evidence of former occupation, 322; west of Lake Titicaca, 323 (ill.)
 Andes, 2; cross section along parallel 24° 43' S., 148 (diagr.), 149; eastern slopes in Bolivia and Peru, 336; land forms, 252; peaks, 252; sky line, 254; western border—recent survey, 264 (map). *See also* Central Andes
 Angelis, Pedro de, 251
 Antiquities, 247
 Antofagasta, 75, 97, 171, 172, 290; artificial character, 110; development, 80; railroad, 235; rain in 1911, 42
 Antofagasta, province of, 251
 Antofagasta de la Sierra, 298 (with ill.)
 Antofalla, Salina de, 265
 Antofalla, volcano of, 262 (ill.)
 Apachetas, 23 (ills.), 24, 103, 258, 282, 305, 306
 Apolobamba, pastures of, 340
 Apurimac, 252
 Arenales, 332
 Arequipa, 94, 346
 Argentina, 97; approaching Atacama across the pampas, 186; cattle trade

- with Copiapó, 107; cross section of life, 188; early northwestern settlements, connection, 108; first city, 104; mountains in the northwest, 189; northwestern, desirability of grassland studies, 317, 318; northwestern, pasture and woodland, 269 (ill.), 270; Puna de Atacama and, 297; Rosario de Lerma sheet, opp. 192 (map); trail from Copiapó into, 106; turno in, 128; woodland and pasture in northwest as affected by climatic change, 317
- Arica, 90; campaign against, 90; fall, 92, 93; hill of, 92 (with ill.)
- Aridity, cumulative effects, 268. *See also* Deserts; Dryness
- Arizaro, Salina de, 265
- Aroma, gorge of, 92
- Arqueros, 169
- Arrenderos, 209, 210; hacendados and, 210, 211 (diagr.)
- Arrieros, 242
- Arroyas, 11
- Ascotan, 81
- Asses, 167, 302-303, 304
- Atacama, 83; Desert and Puna, 259 (map); larger significance, 344, 348; pioneer character, 344; political geography, 83; population by censuses, 175
- Atacama, Desert of, 15, 259 (map), 266; cross section along parallel $24^{\circ} 43' S.$, 148 (diagr.); dryness, 50; general location map, 10; political history, 85, 86; rains and floods, 40, 41 (diagr.); southern margin, 43, 96; vegetation, 61
- Atacama, Puna de, 96, 102, 259 (map); agriculture, 286; cattle drove crossing, 233 (ill.); cattle journeys across, 236; cattle routes across, detailed, 234; climate, 260; cloud zone and woodland and grassland belts on eastern border, 273 (diagr.); contrast with plateaus of Bolivia and Peru, 335; cross section along parallel $24^{\circ} 43' S.$, 148 (diagr.); crossing, 275; definition and description, 257; descent into basin from the east, 276, 277 (ill.); dryness of eastern wall, 260; general location map, 10; geographical significance, 328; habitability in the past, 310; habitations, ancient, 320; highest habitations, 338; human occupation, 294; Indians, conditions, 308; land forms, 252; life of a Puna village, 300; looking east toward mountains, 285 (ill.); mail service, 286; mountain belt, 256; panorama from crest at the eastern border, opp. 278 (ill.); pasturage, 282, 338; political dependence, 295; possible development, 342; secondary ranges on the east, 257; settlements, 294, 338; true character, 265; unfavorable conditions, 295; unifying effect on inhabitants, 330; valleys, basins, and mountains, 261 (diagr.); vegetation, 276; water, 278, 280, 282, 284, 285; weather, 279, 281; western mountain divide, 266; western part, 262 (ill.); wind, 232
- Atacama, Salar de, 243 (ill.), 245 (ill.), 266, 279; camp site on border, 46 (ill.)
- Australia, 339
- Aymará, 2, 72
- Ball, John, 60
- Balmaceda, J. M., 94
- Barco, 104
- Barley, 27, 28, 29, 322
- Basins, 254; desert drainage, 47, 48 (map); dryness and, 268; floods in desert basins, 115; interior, piedmont slopes, 276, 277 (ill.); mountain, 25; Puna and eastern border, 261 (diagr.); shore lines of lakes, 311; woodland and interior basin belts, association, 253 (map)
- Beasts, patron saints of, 305; prayers for, 306
- Belén, 299
- Bella Vista, Salar de, 38
- Bermejo River, 189, 221, 261; region, 227
- Bertrand, Alejandro, 71, 234, 242, 281

- Billingham, G. E., 16, 42
 Bingley, George, 181, 184
 Bohon, Juan, 104
 Bolivia, 25, 81, 83, 193, 302; cattle trade, 214; centers of gravitation, 345; cultivation of high plateau, 331; eastern mountain belt, 336; labor supply, 226; live-stock trade, 202; mountain village, 26; Pacific littoral acquired, 86; railroads, 220; trading methods, 216; wool business, 340, 341
 Bollaert, William, 42, 75, 80
 Bolton, H. C., 159
 Boman, Éric, 18, 224, 286, 300, 302, 320
 Borax, 260, 300, 342; lake, 283 (ill.)
 Border towns, eastern, 186; economic changes, 199
 Bosman, C. J., 143; statistics of Huari fair, 215, 216
 Botijería, 21
 Boundary, Peruvo-Chilean in history, 84
 Bowman, Isaiah, 55, 193, 329, 338
 Boza, R. Dávila, 169
 Braden, 180
 Bramador, El, 155, 158 (ill.), 160 (ill.)
 Brandy, 224
 Brea, 162; houses, 144, 145
 Bresson, André, 171
 Bruch, Carlos, 311
 Brügger, J., 21
 Buckle, H. T., 8
 Buenos Aires, 186, 188, 196, 199
 Bunch grass, 22, 277 (ill.), 282, 283, (ill.), 285 (ill.)
 Burial places, 281
 Bustamente, José, 84
 Cachi, 213, 271, 274, 287
 Cachi, Nevado de, 265
 Cactus, 22, 137; Calchaquí valley growth, 271 (ill.), 274; dense stands, 273; eastern mountain growth, 269 (ill.); shell of cardón, 272 (ill.); structure, 272 (ill.), 274
 Calama, 8, 16, 18, 89, 235, 287; alfalfa pastures, 37 (ills.); importance, 290; snow, 43
 Calchaquí valley, 189, 201, 205 (ill.), 252, 258, 342; desert growth with cactus, 271 (ill.), 274; eastern border—use of the land, 211 (diag.); fertility, 208; importance, 289; life of the people, 212; Poma and, 202, 206 (ill.); upper, 208 (map)
 Caldera, 96, 144, 164, 175, 183; fog, 52; importance, 178; port constructions, 96
 Caleta Buena, 12 (ill.)
 Caleta Molle, 153 (map)
 California, gold discovery, 174
 Callao, 93, 173
 Callalaste, Cordillera de, 265
 Camanchaca, 52
 Camarones, 92
 Camiña, 92
 Campo Negro, 208 (map)
 Campos, 221
 Camps, 243; dry, 276; shepherds, 243 (ill.); temperature, 278
 Canals, irrigation, 112, 321; Pica, 20
 Canchones, 72
 Cane houses, 144, 145
 Cangallero, 168
 Canquilla, 27
 Canyons, 34, 35, 252
 Caracoles (zigzags), 35
 Caracoles mining district, 89, 171, 217, 290
 Cardón, 22, 137; shell, 272 (ill.)
 Carmen, Salar del, 80
 Carnahan, G. H., 266
 Carpa No. 1, 150
 Carrizo, 212
 Casadero, 263 (ill.)
 Caspana, 71
 Castilla, Ramón, 89
 Catamarca, 186, 235, 299
 Catarpe, 242
 Cateadors, 165, 167
 Cattle trade, 134, 183, 292; Argentina and Copiapó, 107; Bolivia, 202, 214; Chaco cattle assembled, 229 (ill.), 230; detailed routes across the Puna de Atacama, 234; driving to the nitrate fields, 230; journeying across the cordillera, 233 (ills.); journeys to market, 214, 228; mines and, 176;

- prices, 230; Salta basin, 193; snow-storm and wind on routes, 280; wet and dry years in relation to, 119
- Cattlemen, 231
- Caya, oasis of, 33, 35, 66
- Cayrani, Finca, 323, 327
- Cayrani valley, 322
- Central Andes, 252, 254; changes in climate and elevation, 310; complexity, 256; cultivation of high plateau, 332; northern and southern sections, contrasts, 334; shepherds' life, 329; Southern Andes compared with, 255
- Central Lagunas, 15, 60
- Cerro de Pasco, 196
- Cerro de plata, 167, 171
- Cerro Palca, looking westward from, 262 (ill.)
- Cerros, 34, 258
- Cerros de la Sal, 34
- Cerruti, A., 234
- Charcarilla canyon, 33
- Charcarilla oasis, 34, 69; forage, price, 66
- Charcarilla valley, story of settlement, 68
- Chaco, 192; gallery forest, 188; grasslands, 218; Indians, 223; population, 227; route across, 220
- Chacra sin riego, 70, 72
- Chacras, 21
- Challapata, 215
- Chañar, 242, 244; tree, 67 (ill.)
- Chañaral, 166, 178, 180
- Chañarcillo, 165, 168, 170, 176
- Changos, 59, 73
- Chaparral, 187
- Chaqueños, 224
- Charles V, 85
- Charqui, 167, 230, 231, 302
- Chaschuil depression, 262 (ill.), 263 (ill.)
- Chicha, 215
- Chilca, 242
- Chilcas, Aguada de, 312, 313
- Children, illegitimate, 304
- Chile, 11; boundary with Peru, 84; coast of northern, 11, 12 (ill.); finances, 88; pastoral industry, 80; rainfall, 43
- Chile saltpeter, 75. *See also* Nitrate
- Chilean revolution of 1891, 94
- Chileans, 101
- Chilenos, 101
- Chincha Islands, 76
- Chinchilla, 138; farming, 140, 141 (ill.); hunting, 140; skin, carving of, 139, 249 (ill.), 251; skins, 142
- Chipana, 76
- Chiuchiu, 71, 235
- Chuculay, Mt., 264 (map)
- Chuño, 231, 244
- Chuquicamata, 180
- Church, G. E., 217
- Church in Poma, 213
- Ciénegas, 286
- City geography in Chile, 109
- Clements, F. E., 317
- Climate, 40, 310; glacial and post-glacial changes, 315; shifting belts on mountain border, 310
- Clothing, 281
- Clouds, 51; Argentina, northwestern, 190 (ill.); eastern border of Puna, effect on woodland and pasture, 273 (diags.); seaward edge of desert, 51 (diagr.), 52, 53, 55
- Coast, 11; fracture and displacement zone, 148 (diagr.), 149, 153 (map); northern Chile, 11, 12 (ill.); trend of movement, 150, 153 (map)
- Coast ports, blockade, 90
- Coast Range, 12; antiquity, 154; cloud bank in Peru, 55; Iquique region, 267 (map); moisture, 51; wet years and dry, 57
- Coast steamers, 78, 79 (ill.)
- Coastal terraces, 150, 151 (ill.)
- Cobija, 73, 290
- Cobos, 224
- Coca, 28, 199, 211, 302
- Cochabamba, 193, 217, 345
- Coipasa, 334
- Cojata, 341
- Cold, 279, 281
- Coletos, 230
- Colonial settlement, 9
- Coloso, 96, 150
- Commerce. *See* Trade

- Community, 347; changing orientation in desert, 251; water supply, 121
- Compañía Agrícola, 134, 135
- Conde Duque, 237 (ill.), 241
- Conduits, 20, 321
- Conquest. *See* Spanish Conquest
- Conquistadores, 84
- Copiapó, 8, 43, 49, 51, 85; cattle trade with Argentina, 107; central plaza, 107 (ill.); changes in life, 106; character, 98, 99; copper period, 174; drought of 1877, 121; drought of 1923, 114; earthquakes, 143; floods, 116; fog and cloud, 52; foundation, 102; geographical situation, 105; history, 99; house types, 144; mining industry, 162; panorama, opp. 110 (ill.); physical basis of life, 109; population, 109, 168, 169; port for, 96, 97; railroad, 176; rainfall, 44, 45, 47, 184 (diagr.); street scene, 107 (ill.); trail to the east, 106; view with river at low water, 98 (ill.); wood supply, 136
- Copiapó Mining Co., 165, 168, 178; earthquake of 1859, 143; records and letters, 180; sketch of mines and estates in 1835, 177 (map), 183-185
- Copiapó River, 113, 115, 185, 280
- Copiapó valley, 266; disposition of cultivated land, 156, 157 (ill.); upper part, opp. 110 (ill.)
- Coposa, 29
- Copper, 88, 100, 163; Copiapó and, 174; mining, 172; modern mines, 180
- Copper Mines of Copiapó, Ltd., 180. *See also* Copiapó Mining Co.
- Coquimbo, 43, 51, 149, 162, 174; copper, 173
- Coquimbo valley, 170
- Cordillera de los Andes, 261, 266
- Cordilleran slopes, 22
- Córdoba, 189, 194
- Corn, 286, 302, 322
- Corocoro, 217
- Corporaca, 196
- Corrals, 212, 296 (ill.), 300, 301 (ill.)
- Corregidor, 341
- Cotton, 164
- Court testimony of heretics, 183
- Cowboys, 229 (ill.), 230
- Cross, wooden, 23 (ill.)
- Crustal movements, 150, 153 (map)
- Cuadra, P. L., 174, 178
- Cúcuter, 242
- Cuesta del Obispo, 204, 257, 261, 273; looking east and west from, 203 (ills.)
- Cueva Negra, 26
- Cuevo, 219
- Cultivation, 321
- Cummings, R. W., 134
- Customhouse, Chilean, 238, 239 (ill.)
- Cuyo, 108, 129
- Cuzco, 340
- Darwin, Charles, 1, 152, 181; on coastal fog, 53; on Copiapó, 169; on effect of a single shower, 50; on the Roaring Mountain of Toledo, 155
- David, T. W. E., 4
- Dávila Boza, Ricardo, 169
- Davis, A. P., 20
- Davis, W. G., 279
- Denis, Pierre, 128, 130, 209
- Derroteros, 167
- Desaguadero River, 334
- Desert settlements, 111; changing orientation, 251; nature and organization, 111. *See also* Oases
- Deserts, 3; Andean desert, 7; borders, 8; campaigning in a desert, 91; Chile, northern, 11; definition of desert, 61; drainage types, 47, 48 (map); floods in basins, 115; fog, 53; inhabitants, 5, 8, 14; isolated settlement, 38; landscape in Chile and in Peru, 11; littoral, 52; moist sand, 56; pavement, 17 (ill.); rainfall, 40; travel, 11, 14; United States, Southwest, 317; vegetation, 60
- Despoblado, 200
- Díaz, Guilberto, 202, 210
- Discovery, 1
- Distance, 345-346
- Domeyko, Cordillera, 142, 171, 264 (map), 266
- Drainage, 47; Andes, 255; desert types, 47, 48 (map); shift in, 320

- Droughts, 6, 118, 268; case of the year 1877 examined, 121; valley community and, 120
 Drunkenness, 294
 Dryness, 6, 40; cumulative effects, 268; fog in relation to, 54
 Dulcinea Mine, 100, 172, 178, 179 (ill.), 185
 Dunes, 17; piedmont slopes east of Pica, 17 (ill.); Roaring Mountain of Toledo, 158 (with ill.), 159, 160 (ill.); wind-rippled, 33 (ill.)

 Earthen houses, 144, 145
 Earthquakes, 143; Copiapó, 143; of 1918, 144; of 1922, 144, 146
 Eastern border, 186; mountains, etc., opp. 192 (map); Puna, 261; towns, 186; towns, economic changes, 199
 Eastern Cordillera, 22, 203 (ill.)
 Economic reorganization, 290, 292
 Eguiguren, Victor, 184
 El Bramador, 155, 158 (ill.), 160 (ill.)
 Electrical works, 39
 El Morro, 92 (with ill.)
 El Totoral, 46 (ill.)
 Embarcación, 219, 220; as a cattle station, 228
 Empexa, Salar de, 29
 Encomiendas, 308
 Escoipe ravine, 189, 197 (ill.), 204, 271
 Escoipe valley, 214
 Exploradora mine, 180
 Estates, 325
 Esteros, 221
 Evans, O. H., 152
 Exploitation, modern, 325
 Exploration, 1, 3

 Fair at Huari, 214, 215
 Fertilizers, 75
 Fiambalá, basin of, 268, 291, 314
 Fiambalá, Sierra de, 263 (ill.)
 Fierro, Alejandro, 85
 Finca Cayrani, 323, 327
 Finca La Poma, 202
 Finca Santa Lucia, ranch house, 195 (ill.)
 Firewood, 15; exploitation, 16; local trade, 136

 Fishermen, 59
 Flamenco, 97, 177, 184
 Floods, 8; Chacarilla valley, 68; desert, 40, 42, 47; desert basins, 115
 Fog, 43, 45, 50; coast, 51; dryness in relation to, 54
 Forage, 340; across the Puna, 282
 Forests, 3; buried, 319; eastern mountain belt of Bolivia and Peru, 336; gallery, 188, 218. *See also* Woodland
 Fortifications of Pucará, 311, 313 (plan)
 Freights, 201, 217, 219
 Frézier, —, 16
 Frontier life, 8, 191; Chaco region, 218
 Copiapó 107, 110
 Frontier town of Salta, 191

 Galería Comiña, 20, 21
 Galleries, water-carrying, 20
 Gallery forest, 188, 218
 Garay, Señor, 155; hospitality, 157-158; ranch house, 155, 156 (ill.)
 Garcilasso de la Vega, 70
 Garua, 43, 52
 Gauchos, 229 (ill.), 230
 Gilliss, —, 75, 165, 169, 178
 Glaciation, 258, 315
 Glaciers, 315, 316
 Goatskins, 189
 Godoy, Juan, 170 (with ill.)
 Gold, discovery in California, 174
 Gold mining, 162
 Gonzales, Señor, 346
 Gormaz, F. V., 152
 Government, 345, 347; handicaps, 347; Indians and, 297; industries and, 113
 Gran Chaco, 218
 Grass, 22; hardy kinds, 340; mountain pasture belt, 22, 24
 Grasslands, 218; Chaco, 218; comparative studies, 317
 Great American Desert, 61
 Grubb, W. B., 221
 Guaitiquina, 238
 Guanaco, 59
 Guano, 75, 76, 83, 87
 Guaqui, 217, 237

- Guardamontes, 229 (ill.), 230
 Güemes, 225
 Guides, 32, 58, 167, 284
- Habas, 189
 Habitation, highest in the world, 338
 Hacendados and arrenderos, 210, 211 (diagr.)
 Hacienda de la Compañía Agrícola, 134, 135 (ill.)
 Hacienda La Poma, 213 (ill.)
 Hacienda Palermo, 205 (ill.)
 Heretics and Christians, 183
 Herrmann, Alberto, 163
 Herzog, Th., 337
 High plateau of Bolivia. *See* Altiplano
 Hilton-Simpson, M. W., 130
 History, geographical knowledge in relation to, 343
 Holmberg, E. A., 214
 Hospitality, 158
 Houses, 300; earthquake effects on various types, 144; types at Copiapó, 144. *See also* Huts
 Huacas, 306
 Huaicho, 341
 Huanillos, 76
 Huantajaya, 169
 Huara, 42
 Huari fair, 214, 215
 Huasco basin, 25
 Huasco Lake, 24, 25
 Huasco River, 133, 280
 Huasco valley, 50, 114, 170; panorama, opp. 110 (ill.); woodland, 136
 Huatacondo, 252
 Human life in the past, 310
 Humboldt Current, 52
 Humidity, coastal, 52
 Huts, 212; Chaco Indians, 226; highest, 212, 301 (ill.); highest in the world, 338; shepherds', 244; shepherds' at high elevation, 275; stone hut of mountain shepherds in winter, 245 (ill.); temporary hut of mountain shepherds, 243 (ill.)
- Ice Age, 315, 316
 Ichu grass, 22, 277 (ill.), 282, 283 (ill.) 285 (ill.)
- Idols, 306
 Illegitimacy, 304
 Ilo, 90
 Inca deity, 305, 306
 Inca Empire, 65, 324
 Inca road, 288; through the desert, 103
 Incas, 100, 102, 163
 Indian blood, 101
 Indians, 59; Chaco country, 223; fisher folk, 59; independence, 297; labor and, 223, 225; Poma region, 209; salt industry and, 303; shyness, 308
 Interior basins. *See* Basins
 Intermont valleys, 202
 Iquique, 13, 21, 91; aridity of region, 268; artificial character, 110; blockade, 89; Coast Range in this region, 267 (map); development, 80; influence, 74; nitrate business, 62; rain of 1911, 43; rainfall, 40; water supply, 78
 Iquique sheet, 33, 34
 Irrigation, 20, 49, 64, 112, 321; alfalfa meadows, 134, 204, 209; Algeria, 130; valley communities and the turno, 120
 Isolation of towns and cities, 110
- Jauja, 196
 Jesús Maria, 163
 Juan, Jorge, 196
 Juan Godoi, 171
 Judge of water, 123, 240
 Jujuy, 186, 303, 304, 308; Puna de, 286, 307, 321
 Juntas, 227
- Kerr, J. G., 221
 Klein, Julius, 331
 Knoche, Walter, 136
 Kühn, Franz, 200, 212, 278
- Labastie, Félipe, 171
 Labor, 81, 223; Chaco Indians, 224, 225; shepherds' and proprietors' arrangements, 326
Lacaw (ship), 87
 La Chimba, 81
 La Gasca, Pedro de, 85
 Laguna Helada, 263 (ill.)

- Lagunas, 38
 Lajas River, 314
 Lakes and shore lines, 311
 Lambrama, Cordillera, 257
 Land, 178; Argentina, 210; Indian view of, 297; usefulness in high plateau of Central Andes, 332; values, 178, 189, 210, 325, 342
 Land forms of the Puna de Atacama, 252
 Landownership, 209
 Lange, Gunardo, 289, 311, 313, 314
 La Noria, 76
 La Paz, 217, 345
 La Poma, 202, 208; ranch house, 213 (ill.)
 Laqueca, 27
 Lari, Alto de, 281
 Láscar, 279
 Latrille, Roch, 70
 Lava flows, 207, 258, opp. 278 (ill.)
 League, 221
 Ledesma, 189
 Leña barrilla, 137
 Lerma basin, 192, 201
 Lezaeta, L. S., 102, 105
 Lima, 52, 83, 93, 94, 108, 196
 Linnemann, Clemens, 144, 145
 Lípez, 164
 Lípez River, 268
 Livingstone, David, 4
 Llama wool ropes, 244
 Llamas, 24, 194, 302, 303, 342; carvings of, 249 (ill.), 250; drove near San Pedro de Atacama, 245 (ill.)
 Llanos, 34
 Llareta, 136, 284
 Llica, 26, 28
 Lloyd, J. A., 171
 Llullaillaco, Mt., 149, 264 (map)
 Loa River, 11, 16; valley fertility, 38; valley pastures, 37 (ill.)
 Lobos Islands, 76, 83
 Locumba River, 90
 Lopez Loayza, Fernando, 78
 Loria, Achille, 9
 Lorima, Mt., 25
 Lost trail, 29
 Lumber in Argentina, 188
 Luracatao, 214
 Macaya, 72
 Machetes, 288
 Machuca, Lozano, 59
 Mackenna, B. Vicuña, 167, 174
 Macleod, J. M., 95
 McQueen, C. A., 88
 Mails, 286
 Maize, 321
 Malaspina, Alejandro, 84
 Mani, Quebrada de, 70
 Manrique, Juan del Pino, 251
 Manzano River, 204
 Marine shells, 150, 154
 Marine terraces, 150, 151 (ills.)
 Maritime Cordillera, 261
 Markham, Clements, 310
 Marriage among the Susques Indians, 304
 Matacos, 223
 Maté, 199, 225
 Mather, K. F., 219, 220
 Matilla, frontispiece (ill.), 8, 15, 19, 73, 78
 Matta, J. G., 178
 Mauri River, 268
 Mawson, Sir Douglas, 4
 Measurement of water in Algeria, 131
 Médanos. *See* Dunes
 Medina, J. T., 85
 Mejillones, 81, 290
 Mendoza, 128, 256
 Mercedario, 252
 Migrations, 6, 244
 Miller, B. L., 180
 Miña, 326
 Mines, 71; trade with, 67
 Mining industry, 119; cattle trade and, 292; climatic handicap, 165; desert settlement, influence on, 162; railroads and, 328; relation of rainfall to, 119; types of life, 167
 Mirage, 160 (ill.)
 Mohave desert, 317, 318
 Molina, J. I., 85, 173
 Molinos, 189, 200
 Mollendo, 58, 93; coastal terrace, 151 (ill.), 152
 Montaña, 197 (ill.); settlement, 195 (ill.)
 Monte, 187, 221

- Monte la Soledad, 37 (ill.), 38, 112
 Monte Lindo, Riacho, 222
 Montessus de Ballore, F., 143
 Moquega, 90
 Morro, El., 92 (with ill.)
 Mossman, R. C., 52
 Motor trucks, 80
 Mountain sickness, 294. *See also*
 Altitude
 Mountain streams, 64. *See also* Rivers
 Mountains, 3; Argentina, northwestern,
 189; as barriers between peoples,
 328, 348; highest peaks, 252; inter-
 relation with plains, 336, 337; man's
 relation to, in the south, 255; old
 range, undissected portions, 203
 (ill.); railroads as conquerors, 7;
 Roaring Mountain of Toledo, 155,
 158 (ill.), 160 (ill.); scenery in
 northern Chile, 13; settlements, 26;
 timidity of natives, 27
 Mud houses, 144, 145
 Mules, 14 (ill.); forage for, across the
 Puna, 282, 284; mining industry and,
 165; pack train, 197 (ill.); supply,
 176, 194; trade and transport on
 eastern border, 192; value as beast
 of burden, 194
 Muleteers, 196, 210, 242, 284
 Muñoz, Santiago, 103, 200
 Murphy, R. C., 76
 Murray, Sir John, 134, 135; chinchilla
 farm, 140, 141 (ills.)

 Nevado de Cachi, 203 (ill.), 205 (ill.),
 265
 Nevado Ojo de las Losas, looking
 northward from, 262 (ill.); pano-
 rama from, opp. 278 (ill.)
 Nevado San Francisco, panorama,
 opp. 278 (ill.)
 Newspapers, 110
 Nitrate, 16, 63; Iquique and, 62;
 significance as a national resource, 87
 Nitrate desert, 13; development, 73;
 population groups, 60; rains and
 floods, exceptional, 40
 Nitrate industry, 342; labor supply, 81;
 provisioning, 76, 79 (ill.); relation of
 water supply to, 118

 Nitrate works, 18, 36, 39; oases popu-
 lation and, 73
 Nordenskiöld, Erland, 220, 250
 Nordenskiöld, Otto, 152
 Nuestra Señora, 86

 Oases, 14; Caya, 33; Monte la Soledad,
 37 (ill.); economic life, 238; mountain
 shepherd and, 247; nitrate settle-
 ments and, 73; persistent character of
 towns, 70; piedmont, 18; sedentary
 character, 72; situation, 64; trade
 limitations, 65; two kinds, 50; water
 supply, 19
 Obispito, 96, 165, 166
 Obispo, Cuesta del, 204, 257, 261, 273;
 looking east and west from, 203
 (ills.)
 Ogilvie, A. G., 75
 O'Higgins, Bernardo, 164
 Oil, 219
 Old customs, 247
 Oruro, 81, 196, 217, 290, 345

 Pabellon de Pica, 76
 Pachamama, 305, 306
 Paciencia, Llano de la, 34
 Pack train, 14 (ill.), 197 (ill.)
 Pacocha, 90
 Page, T. J., 201
 Paíta, 93, 150; coastal terrace, 150,
 151 (ill.)
 Paja brava, 299
 Pajonales, 45, 246, 299
 Palca, Cerro, 262 (ill.)
 Palermo, 204; Hacienda, 205 (ill.)
 Palma, 221
 Pampa, 13; Argentina, 186
 Pampa Peñon, 264 (map)
 Paposo, 50, 52, 59, 60, 85, 166; bay of,
 86
 Passes, 256, 260, 287, 289
 Pastoral industry, 326, 329; Chile, 80;
 utilization of high pastures, 338
 Pastos de cerros, 299
 Pastos Grandes, 275, 285 (ill.); stone
 shelters near, 296 (ill.), 300
 Pastos Grandes, Salina de, 265; north-
 ern border, opp. 278 (ill.)
 Pastures, 22, 24, 299; alpaca in Bolivia,

- 340; Andes, 339; northwestern Argentina, as affected by climatic change, 317; oases in the Puna de Atacama, 246; Puna de Atacama, 338, 340; rainfall and, 57, 58; woodland and, 269 (ills.), 270; woodland and, on eastern border, 273 (diagrs.)
- Pata del oro, 137
- Patagonia, 255, 256
- Pavement, desert, 17 (ill.)
- Peaks, 252
- Peary, R. E., 4
- Peña, petroglyphs, 249 (ills.)
- Peñas Blancas, 212, 258, 260, 274, 275, 338; hut and corral, 301 (ill.)
- Penck, Walther, 261, 263, opp. 278, 292, 314, 316
- Peñon Syndicate, 264, 266
- Peon de campo, 224
- Peons, 210, 326
- Pepper tree, 156 (ill.)
- Perico, 225
- Perkins, F. N., 181
- Peru, 51; coastal belt fogs and rains, 52, 55; cultivation of high plateau, 331; eastern mountain belt, 336; revolutions, 346; viceroyalty of, 108
- Peruvian worship, 306
- Peruvo-Chilean boundary, 84
- Pesse, A., 171
- Petroglyphs, 249 (ills.), 250
- Philippi, R. A., 169, 174
- Pica, 8, 19, 71, 72, 73, 78; forage, price, 66; water tunnels, 20
- Pica, Altos de, 19, 24, 34
- Pictographs, 250
- Piedmont, eastern border of intermont basins, 276, 277 (ill.)
- Piedmont oases, 18. *See also* Oases
- Pilcomayo River, 221
- Piles of stones, 23 (ill.), 24, 103, 282, 288
- Pingo-pingo, 241 (ill.), 242, 299
- Pioneer life, 344; Chaco region, 218
- Pioneers, 4
- Pique, 36
- Pircas, 103
- Pisagua, 16, 78, 89, 95; flood, 42
- Piura rains, 184 (diagr.)
- Pizarro, Francisco, 84
- P'acilla, 171
- Plagemann, A., 16, 250
- Plains, interrelations with mountains, 336, 337
- Plant geography of Bolivia and southern Peru, 337
- Plata region, 108, 186, 199
- Playa Blanca, 80
- Playa lands, 189
- Pneumonia, 294
- Poisonous grass, 284, 299
- Polar regions, 1, 3, 4
- Political geography of Atacama, 83
- Political refugees, 237
- Political unity, 345
- Poma, 214, 257, 275; Calchaquí valley and, 202; houses, 213; main street, 212 (ill.); route to, 204; site, 207
- Ponchos, 231
- Poopó, Lake, contrast with Lake Titicaca, 334
- Population, 60; density, 343; effect of Spanish Conquest, 324; nitrate desert, 60; towns in Chile, 110
- Ports, 166; Atacama Desert, 97; trade, 175
- Porunero, 168
- Potosí, 163, 164, 193, 251, 290
- Pozo Almonte, 78; flood, 42
- Precipitation. *See* Rainfall
- Pre-Cordillera, 289
- Prices of commodities, 65
- Prospectors, 165, 167
- Provisions for the nitrate industry, 76, 78, 79 (ill.)
- Pucará, 248 (with ill.), 250; Andalgala, 311; pass of, 289; Rinconada, 320
- Puerto Acosto, 341
- Puerto Caldera, 162
- Puerto Viejo, 97, 178
- Puna. *See* Atacama, Puna de
- Puno, 237
- Punta de Foca, 150
- Punta Negra, Salar de, 266, 267
- Puquios, 172, 178, 179
- Pyrenees, 330
- Quebracho, 221
- Quebradas, 24
- Quechua, 2, 72, 163

- Queñoa, 284
 Quillagua, 8, 38, 60
 Quimal, Llano del, 34
 Quinoa, 28, 29
 Quiron, Salar de, 282, 283 (ill.)
 Quisco, 137
 Quisma, Quebrada de, 19, 78

 Railroads, 70, 89, 95, 216; Antofagasta, 235; Argentine connection with Chile, 97; Bolivia, 220; Chaco, 219; conquest of mountain and desert, 7; Copiapó, 176; earliest, 176; mining industry and, 328; pack trains and, 71; primitive nature of trains, 111; sail car, 79 (ill.); trail vs. railroad, 290
 Rainfall, 19; Argentina, northwestern, 270; Chile, 43; Copiapó and Piura, 184 (diagr.); Copiapó chances, 113; cultivation in relation to, 49; curve and prediction, 184 (diagr.), 185; dates and amount 1888-1913, 44; dependence of the people on, 117; desert, 40, 41 (diagr.); limits of zone of maximum in present and in Pleistocene time, 316 (diagr.); Peru, coastal belt, 55; rains of 1911, 42; salars in relation to, 335; single shower, effect, 50, 114; temperatures and, in the Puna, 278; transportation rates in relation to, 58; wet years and dry years, 118; year of abundant, 132
 Ramón, García, 172
 Ranch for raising alfalfa and live stock, 134
 Ranch house at Finca Santa Lucia, 195 (ill.)
 Ranges and their products, 339
 Ravines, 34, 35
 Red sandstone, 258
 Regionalism, 348
 Religion, 72; miners', 168; mixture of rites, 72; services of priest, 213; Susques Indians, 304, 305
 Reorganization, economic, 292; commercial companies, 292; railroads, 290
 Reservoirs, 78
 Revolutionists, 237
 Revolutions, 109, 346; Chile, 1891, 94
 Richards Deep, 148 (diagr.)
 Rincon, 282, 284
 Rinconada, 250, 307; Pucará ruin, 320
 River steamers, 227
 Rivers, 11; basis of life, 111; clearing bed, 197 (ill.); dependence of oases on mountain streams, 64; Puna, eastern border, 261
 Roads, desert, 103, 104
 Roaring Mountain of Toledo, 155, 158 (ill.), 160 (ill.)
 Roca, J. A., 198
 Rogers, Mr., 24
 Romaña estate, 327
 Roosevelt, Theodore, 1, 4, 218
 Rosario, 187, 201
 Rosario de Lerma, 191, 204, 257, 271
 Rosario de Lerma sheet, opp. 192 (map)
 Routes across the Cordillera from the east, 199-200. *See also* Trails
 Rubber forests, 325
 Ruins at Pucará, 311, 313 (plan)

 Sahara, 61
 Saints, 72, 305, 306
 Sajama, 252
 Sal, Cerros de la, 34
 Salado River, 85, 201
 Salars, 18, 265, 283 (ills.), 303, 335
 Salinas, 81, 263 (ill.), 265
 Salinas Grandes, 303, 306
 Salitreras, 42, 78, 80
 Salt, 260, 268; ancient industry, 303; cost, 176; fields, 263 (ills.); incrustations, 49
 Salt basins in the Puna, 282, 283 (ills.)
 Salta, 97, 104, 186, 303, 304; as route station, 198; basin, 148 (diagr.), 190 (ill.), 191; development, recent, 191
 Saltpeter, Chile, 75. *See also* Nitrate
 Sama River, 83, 90
 San Andrés, 72
 San Antonio de los Cobres, 200, 295, 298, 338
 San Felix, 147
 San Francisco, battle of, 91

- San Francisco, volcano, 262 (ill.)
 San Francisco de la Selva, 136, 163
 San Isidro, 72
 San Juan, 123
 San Lorenzo Islands, 93
 San Pedro de Atacama, 8, 24, 71, 73, 96, 102, 171, 172, 237 (ill.), 280, 287; cattle station, 232; cattle trade, 235, 236; changing orientation, 251; economic life, 238; population, 241; situation, 236; snow, 43; villages, 242; water rights, 240
 San Roman, F. J., 16, 42, 168
 Sanchez, P. O., 80
 Sand, sonorous, on the Roaring Mountain of Toledo, 158, 159, 160 (ill.)
 Sand dunes. *See* Dunes
 Santa Cruz de la Sierra, 219, 225
 Santa Fé, 39
 Santa Rosa, 169
 Santiago, 85, 86, 110
 Santiago del Estero del Nuevo Maestrazgo, 104
 Sauce, 242
 Sayago, C. M., 105, 164
 Sayate, Arroyo de, 321
 Scenery, Andes peaks, 252, 254; nitrate desert, 13
 Sea control, 89; continued importance, 93
 Sea journeys in colonial period, 103
 Seggia, 130
 Serena, 43, 104; mint, 170
 Settlements, 60; effect of Spanish Conquest on human life, 324; effect of uplift in the past, 310; Puna, 294; Puna distribution, 297
 Sheep, 306, 308, 326, 342
 Shells, marine, 150, 154
 Shelters, 281, 296 (ill.), 300
 Shepherds, 238; arrangements with proprietors of large estates, 326; camp and hut, 243 (ills.); mountains not barriers to, 329; Puna, 295; two residences, 246; winter encampment, 245 (ill.)
 Shipping, 183; mining and, 173
 Shoemaker, F. C., 61
 Shore lines of lakes, 311
 Showers, 114; effect of a single shower, 50
 Shrines, 282
 Signos del camino, 288
 Sililica, Cordillera, 15, 23 (ill.), 25, 254
 Silver discoveries, 169
 Silver mining, 164
 Sinai, sonorous sand, 159
 Singewald, J. T., Jr., 180
 Sitalca, Altos de, 34
 Snow, 30, 117, 260; camping and traveling in, 32; floods and, 47; heavy storms, 43, 280; in the desert, 240; rivers in relation to, 280
 Snow line, 315, 316
 Socaire, 247
 Soncor, 24, 234, 247; oasis of, 239 (ill.)
 Sorata, 217
 Soroche, 294, 306
 Sotomayor, Colonel, 89
 South Africa, 339
 Southern Andes compared with Central, 255
 Spaniards, 84, 102, 112, 344
 Spanish Conquest, effect on population distribution, 324
 Springs in the Chaco, 223
 Stability of life, 110
 Steam navigation, 173, 183
 Steamers, coast, 78, 79 (ill.)
 Stefansson, Vilhjalmur, 4
 Stone shelters, 281, 296 (ill.), 300
 Stream bed, 197 (ill.)
 Sucre, 193, 345
 Sugar industry, 188; labor needs, 224, 225
 Suisiuga, 27, 29
 Susques, 298, 300, 302
 Sutcliffe, Thomas, 174
 Tabular masses, 34
 Tacna, 43, 90, 91
 Tacna-Arica Conference, 83
 Talaje, 176
 Talina, 303
 Taltal, 71, 74 (ills.), 149; water system, 77 (ill.)
 Tamarugal, Pampa del, 16, 38; agricultural experiments, 70
 Tamberias, 103

- Tambillo, 19, 46 (ill.), 238, 279
 Tanning, 138
 Tarapacá, 16; coast ports, 90; nitrate beds, 88; nitrate industry and population, 82
 Tarapacá, Desert of, 16; buried algarrobo forests, 319; extreme dryness, 62
 Tarapacá, Quebrada de, 22
 Temperatures and rainfall in the Puna, 278
 Terminal moraines, 258
 Terraces, 320, 326. *See also* Andenes
 Terraces, marine, 150, 151 (ills.)
 Territorio de los Andes, 297
 Teuco River, 227, 228
 Tevinguicha, 242
 Tierra Amarilla, 116, 117
 Tilomonte, 103, 247
 Tinogasta, 97, 314; importance, 291
 Tintín, plain of, 274
 Tintín, Sierra de, 204
 Tirana, 16, 70
 Titicaca, Lake, 217, 237; contrast with Lake Poopó, 334; valley slopes west of, 322, 323 (ill.)
 Tobacco, 226
 Tobas, 223
 Toconao, 240, 246, 247
 Tocopilla, 60, 290
 Tola, 22, 24, 137, 276, 282, 284, 299
 Tolderías, 226
 Toldo, 222
 Toledo, 155; Roaring Mountain, 155, 158 (ill.), 160 (ill.)
 Tolilla, 137
 Torata, 90
 Totoral, El, 46 (ill.)
 Towns, 64; dependence on environing country, 109; desert, character, 64, 70; size, census statistics, 110
 Trade, 65; methods in Bolivia, 216; relocation, 290, 292
 Trail markers, 288
 Trails, 18; across the Puna de Atacama, 287; cattle routes, detailed across the Puna de Atacama, 234; cattle trails from the Chaco to the nitrate fields, 231; cordilleran slopes, 22; desert, 18; dry-weather and wet-weather, 22; hot and sandy, 46 (ill.); losing a trail, 29; permanence, 288; railroad vs. trail, 290
 Transportation, 58; Bolivia, 217; cost, 219; eastern border, 193; mining industry and, 165, 172, 175; mountains and the mining industry, 328; rains in relation to rates, 58. *See also* Freights
 Tres Cruces, 316
 Tres Cruces pass, 200
 Tres Puntas, 171
 Tropical forests, 3
 Troussu, Pierre, 20
 Trujillo, 52
 Tschudi, J. J. von, 252
 Tucumán, 104, 186, 187, 188, 289
 Tunilla, 140
 Tunnels, water, 20
 Tupiza, 102, 193
 Turner, F. J., 9
 Turno, law of the, 119; Argentina, 128; documents showing the working of the law, 121, 124, 128
 Ulloa, Antonio de, 196
 United States, Great Plains and deserts, 61; Southwest, 317
 Uplift, 150, 154; effect on settlement, 310
 Upper Peru, 192, 193, 196
 Uros, 59
 Uyuni, 331
 Uyuni, Salar de, 254, 268, 294, 334, 335
 Valdivia, Pedro de, 84, 85, 102
 Valle de la Posesión, 102
 Vallenar, 45, 49, 51, 135 (ills.); drought in 1913, 114; earthquake, 146, 147; panorama, opp. 110 (ill.); rainfall, 133; silver mines near, 169
 Valleys, 98; Chilean, 103; Copiapó, 102, 105; intermont, 202; sand-choked valley, 31 (ill.); stability of life in, 112
 Valparaiso, 95, 110, 173
 Vaqueanos, 167
 Vegas, 265, 276
 Vegetation, 60, 317

- Victoria copper mines, 35
 Vicuña hunting, 247
 Viento blanco, 232, 281
 Vilcapampa, Cordillera, 315
 Villa Concepción, 221
Ville du Havre, 79 (ill.)
 Vizcacha, 25, 139
 Vizcachera, 284, 299
 Volcanoes, 25, 46 (ill.), 258, 260, 264 (map), 276; Central Andes, 254; Poma, 207; volcanic country, 31 (ill.)
 Wakefield, H. F., 134
 War of the Pacific, 83, 183, 297; strategy, 89
 Water, 8; Chaco, 222; Chilean coast streams, 11, 12; cost and scarcity, 171; government control, 113; oases, supply, 19; recovery in the desert, 20; struggle for, 119; waste, 319
 Water clock, 131
 Water rights, 182; Argentina, 128; San Pedro de Atacama, 240
 Water supply, 49; Africa, 130; hauling water by mules, 77 (il's.); mining demands at Copiapó, 163; nitrate industry, 76; Pucará, 312; Puna de Atacama, 278, 280, 282, 284, 285; quarrels about, 123, 164, 209; Sayate, 321; turno law, 119; two elements in the desert, 117. *See also* Turno
 Water tunnels, 20
 Watson, Mr., 15
 Weather, 54
 Western Cordillera, 34, 245 (ill.), 262 (ill.); crossing in face of the wind, 278
 Wheat, 174, 339
 Wheelwright, William, 173, 176
 Willis, Bailey, 92, opp. 110, 146, 147
 Willow, 242
 Wilson, H. M., 20
 Wind, 79; Argentina, northwestern, 270; Puna de Atacama, 232, 276, 278; sail car on railroad, 79 (ill.)
 Wine making, 162
 Wood, 136. *See also* Firewood
 Woodcutter, 15
 Woodland, 187, 221; Argentina, northwestern, 190 (ill.); Argentina, northwestern, as affected by climatic change, 317; eastern border of Andes, outliers, 198 (ill.); interior-basin belt associated with, 253 (map); mountain slopes west of Salta, 269 (ill.); pasture and, 269 (ills.) 270; pasture and, on eastern border, 273 (diags.). *See also* Montaña
 Wool, 302, 305, 308; alpaca, 340, 341
 Worship, 72, 168, 213; Peruvian, 306; Susques Indians, 304, 305
 Wrigley, G. M., 192
 Yacuiba, 219, 225
 Yerba, 225
 Yungas, 211, 336
 Zápar, 246



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